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A DICTIONARY OF ARTS, MANUFACTURES, AND MINES;

CONTAINING

A CLEAR EXPOSITION OF THEIR PRINCIPLES AND PRACTICE.

BY

ANDREW URE, M. D.;

F.R.S. M.G.S. M.A.S. LOND.: M. ACAD. N.S. PHILAD.; S. PH. SOC. N. GERM.
HANOV.; MULII. ETC. ETC.

ILLUSTRATED WITH TWELVE HUNDRED AND FORTY ENGRAVINGS ON WOOD

IN TWO VOLUMES.

VOL. II.

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LABDANUM, or LADANUM, is an unctuous resin, of an agreeable odor, found besmearing the leaves and twigs of the *cystus creticus*, a plant which grows in the island of Candia, and in Syria. It is naturally a dark-brown soft substance, but it hardens on keeping. Its specific gravity is 1·186. It has a bitter taste. Its chief use is in surgery for making plasters.

LABRADORITE, opaline, or Labradore feldspar, is a beautiful mineral, with brilliant changing colors, blue, red, and green, &c. Spec. grav. 2·70 to 2·75. Scratches glass; affords no water by calcination; fusible at the blowpipe into a frothy bead; soluble in muriatic acid; solution affords a copious precipitate with oxalate of ammonia. Cleavages of 93½° and 86½°; one of which is brilliant and pearly. Its constituents are silica, 55·75; alumina, 26·5; lime, 11; soda, 4; oxyde of iron, 1·25; water, 0·5.

LABYRINTH, in metallurgy, means a series of canals distributed in the sequel of a stamping-mill; through which canals a stream of water is transmitted for suspending, carrying off, and depositing, at different distances, the ground ores. See METALLURGY.

LAC, LAC-DYE (*Laque*, Fr.; *Lack*, *Lackfarben*, Germ.). *Stick-lac* is produced by the puncture of a peculiar female insect, called *coccus lacca* or *ficus*, upon the branches of several plants; as the *ficus religiosa*, the *ficus indica*, the *rhamnus jujuba*, the *croton lacciferum*, and the *butea frondosa*, which grow in Siam, Assam, Pegu, Bengal, and Malabar. The twig becomes thereby incrusted with a reddish mammelated resin, having a crystalline-looking fracture.

The female lac insect is of the size of a louse; red, round, flat, with 12 abdominal circles, a bifurcated tail, antennæ, and 6 claws, half the length of the body. The male is twice the above size, and has 4 wings; there is one of them to 5000 females. In November or December the young brood makes its escape from the eggs, lying beneath the dead body of the mother; they crawl about a little way, and fasten themselves to the bark of the shrubs. About this period the branches often swarm to such a degree with this vermin, that they seem covered with a red dust; in this case, they are apt to dry up, by being exhausted of their juices. Many of these insects, however, become the prey of others, or are carried off by the feet of birds, to which they attach themselves, and are transplanted to other trees. They soon produce small nipple-like incrustations upon the twigs, their bodies being apparently glued, by means of a transparent liquor, which goes on increasing to the end of March, so as to form a cellular texture. At this time, the animal resembles a small oval bag, without life, of the size of cochineal. At the commencement, a beautiful red liquor only is perceived, afterwards eggs make their appearance; and in October or November, when the red liquor gets exhausted, 20 or 30 young ones bore a hole through the back of their mother, and come forth. The empty cells remain upon the branches. These are composed of the milky juice of the plant, which serves as nourishment to the insects, and which is afterwards transformed or elaborated into the red coloring matter that is found mixed with the resin, but in greater quantity in the bodies of the insects, in their eggs, and still more copiously in the red liquor secreted for feeding the young. After the brood escapes, the cells contain much less coloring matter. On this account, the branches should be broken off before this happens, and dried in the sun. In the East Indies this operation is performed twice in the year; the first time in March, the second in October. The twigs incrusted with the radiated cellular substance constitute the *stick-lac* of commerce. It is of a red color, more or less deep, nearly transparent, and hard, with a brilliant conchoidal fracture. The stick-lac of Siam is the best; a piece of it presented to me by Mr. Rennie, of Fenchurch-street, having an incrustation fully one quarter of an inch thick all round the twig. The stick-lac of Assam ranks next; and last, that of Bengal, in which the resinous coat is scanty, thin, and irregular. According to the analysis of Dr. John, stick-lac consists, in 120 parts, of—

An odorous common resin	80·00
A resin insoluble in ether	20·00
Coloring matter analogous to that of cochineal	4·50
Bitter balsamic matter	3·00
Dun yellow extract	0·50
Acid of the stick-lac (laccic acid)	0·75
Fatty matter, like wax	3·00
Skin of the insects and coloring matter	2·50

Salts	1·25
Earths	0·75
Loss	4·75
	120·00

According to Franke, the constituents of stick-lac are, resin, 65·7; substance of the lac, 28·3; coloring matter, 0·6.

Seed-lac.—When the resinous concretion is taken off the twigs, coarsely pounded, and triturated with water in a mortar, the greater part of the coloring matter is dissolved, and the granular portion which remains, being dried in the sun, constitutes *seed-lac.* It contains of course less coloring matter than the stick-lac, and is much less soluble. John found in 100 parts of it, resin, 66·7; wax, 1·7; matter of the lac, 16·7; bitter balsamic matter, 2·5; coloring matter, 3·9; dun yellow extract, 0·4; envelopes of insects, 2·1; laccic acid, 0·0; salts of potash and lime, 1·0; earths, 6·6; loss, 4·2.

In India the *seed-lac* is put into oblong bags of cotton cloth, which are held over a charcoal fire by a man at each end, and, as soon as it begins to melt, the bag is twisted so as to strain the liquefied resin through its substance, and to make it drop upon smooth stems of the banyan tree (*musa paradisa*). In this way, the resin spreads into thin plates, and constitutes the substance known in commerce by the name of *shellac.*

The Pegu stick-lac, being very dark-colored, furnishes a shellac of a corresponding deep hue, and therefore of inferior value. The palest and finest shellac is brought from the northern *Circar.* It contains very little coloring matter. A stick-lac of an intermediate kind comes from the Mysore country, which yields a brilliant lac-dye and a good shellac.

Lac-dye is the watery infusion of the ground stick-lac, evaporated to dryness, and formed into cakes about two inches square and half an inch thick. Dr. John found it to consist of coloring matter, 50; resin, 25; and solid matter, composed of alumina, plaster, chalk, and sand, 22.

Dr. Macleod, of Madras, informs me that he prepared a very superior lac-dye from stick-lack, by digesting it in the cold in a slightly alkaline decoction of the dried leaves of the *Memecylon tinctorium* (perhaps the *M. capitellatum,* from which the natives of Malabar and Ceylon obtain a saffron-yellow dye). This solution being used along with a mordant, consisting of a saturated solution of tin in muriatic acid, was found to dye woollen cloth of a very brilliant scarlet hue.

The cakes of *lac-dye* imported from India, stamped with peculiar marks to designate their different manufacturers, are now employed exclusively in England for dyeing scarlet cloth, and are found to yield an equally brilliant color, and one less easily affected by perspiration than that produced by cochineal. When the lac-dye was first introduced, sulphuric acid was the solvent applied to the pulverized cakes, but as muriatic acid has been found to answer so much better, it has entirely supplanted it. A good *solvent* (No. 1) for this dye-stuff may be prepared by dissolving three pounds of tin in 60 pounds of muriatic acid, of specific gravity 1·19. The proper *mordant* for the cloth is made by mixing 27 pounds of muriatic acid of sp. grav. 1·17, with 1½ pounds of nitric acid of 1·19; putting this mixture into a salt-glazed stone-bottle, and adding to it, in small bits at a time, grain tin, till 4 pounds be dissolved. This solution (No. 2) may be used within twelve hours after it is made, provided it has become cold and clear. For dyeing, three quarters of a pint of the solvent No. 1 is to be poured upon each pound of the pulverized lac-dye, and allowed to digest upon it for six hours. The cloth, before being subjected to the dye-bath, must be scoured in the mill with fullers' earth. To dye 100 pounds of pelisse cloth, a tin boiler of 300 gallons capacity should be filled nearly brimful with water, and a fire kindled under it. Whenever the temperature rises to 150° Fahr., a handful of bran and half a pint of the solution of tin (No. 2) are to be introduced. The froth, which rises as it approaches ebullition, must be skimmed off; and when the liquor boils, 10½ pounds of lack-dye, previously mixed with 7 pints of the solvent No. 1, and 3½ pounds of solution of tin No. 2, must be poured in. An instant afterwards, 10½ pounds of tartar, and 4 pounds of ground sumach, both tied up in a linen bag, are to be suspended in the boiling bath for five minutes. The fire being now withdrawn, 20 gallons of cold water, with 10½ pints of solution of tin, being poured into the bath, the cloth is to be immersed in it, moved about rapidly during ten minutes; the fire is to be then rekindled, and the cloth winced more slowly through the bath, which must be made to boil as quickly as possible, and maintained at that pitch for an hour. The cloth is to be next washed in the river; and lastly, with water only, in the fulling mill. The above proportions of the ingredients produce a brilliant scarlet tint, with a slightly purple cast. If a more orange hue be wanted, white Florence argal may be used, instead of tartar, and some more sumach. Lac-dye may be substituted for cochineal in the orange-scarlets; but for the more delicate pink shades, it does not answer so well, as the lustre is apt to be impaired by the large quantity of acid necessary to dissolve the coloring matter of the lac.

Shellac, by Mr. Hatchett's analysis, consists of resin, 90·5; coloring matter, 0·5; wax, 4·0; gluten, 2·8; loss, 1·8; in 100 parts.

The resin may be obtained pure by treating shellac with cold alcohol, and filtering the solution in order to separate a yellow gray pulverulent matter. When the alcohol is again distilled off, a brown, translucent, hard, and brittle resin, of specific gravity 1·139, remains. It melts into a viscid mass with heat, and diffuses an aromatic odor. Anhydrous alcohol dissolves it in all proportions. According to John, it consists of two resins, one of which dissolves readily in alcohol, ether, the volatile and fat oils; while the other is little soluble in cold alcohol, and is insoluble in ether and the volatile oils. Unverdorben, however, has detected no less than four different resins, and some other substances, in shellac. Shellac dissolves with ease in dilute muriatic and acetic acids; but not in concentrated sulphuric acid. The resin of shellac has a great tendency to combine with salifiable bases; as with caustic potash, which it deprives of its alkaline taste.

This solution, which is of a dark red color, dries into a brilliant, transparent, reddish brown mass; which may be re-dissolved in both water and alcohol. By passing chlorine in excess through the dark-colored alkaline solution, the lac-resin is precipitated in a colorless state. When this precipitate is washed and dried, it forms, with alcohol, an excellent pale-yellow varnish, especially with the addition of a little turpentine and mastic.

With the aid of heat, shellac dissolves readily in a solution of borax.

The substances which Unverdorben found in shellac are the following:

1. A resin, soluble in alcohol and ether;
2. A resin, soluble in alcohol, insoluble in ether;
3. A resinous body, little soluble in cold alcohol;
4. A crystallizable resin;
5. A resin, soluble in alcohol and ether, but insoluble in petroleum, and uncrystallizable.
6. The unsaponified fat of the *coccus* insect, as well as oleic and margaric acids.
7. Wax.
8. The *laccine* of Dr. John.
9. An extractive coloring matter.

STATISTICAL TABLE of LAC-DYE and LAC-LAKE, per favor of James Wilkinson, Esq., of Leadenhall street.

	Import.	Export.	Home Consumption.	Prices.	Stocks.
	lbs.	*lbs.*	*lbs.*		
1802	253		none		
1803	1,735	none	account burned		
1804	531	–			
1805	1,987				
1806	none				
1807	25,350				
1808	5,731				
1809	40,632				
1810	235,154				
1811	378,325				
1812	198,250				
1813	289,654				
1814	278,899	5,071	133,935		
1815	598,592	8,441	137,915		
1816	269,373	27,412	162,894		
1817	384,909	23,091	234,768		
1818	242,572	32,079	323,169		
1819	179,511	21,707	207,063		
1820	441,486	49,519	912,514		
1821	641,755	91,925	322,837		
1822	872,967	29,578	349,351		
1823	534,220	13,050	414,714		
1824	604,269	53,843	483,339		
1825	541,443	61,908	385,734		
1826	760,729	68,603	395,609		

STATISTICAL TABLE of LAC-DYE and LAC-LAKE.—*continued.*

	Import.	Export.	Home Consumption.	Prices.		Stocks.
	lbs.	*lbs.*	*lbs.*	*s. d.*	*s. a.*	*Chests.*
1827	756,315	76,875	448,270	1 9	4 0	11,538
1828	512,874	54,999	397,867	1 3	3 9	11,085
1829	475,632	39,344	433,851	1 3	3 6	11,976
1830	534,341	78,099	548,865	0 9	3 3	11,834
1831	913,562	175,717	597,568	0 4	2 6	12,559
1832	378,843	69,842	594,155	0 4	2 3	11,420
1833	326,894	66,447	426,460	0 9	2 4	11,457
1834	708,959	89,229	398,832	0 11	2 4	11,928
1835	528,564	203,840	573,288	0 11	3 0	10,454
1836	642,436	200,975	642,615	1 0	4 0	9,492
1837	1,011,674	133,959	427,890	1 0	3 9	8,780

The stock includes 2,200 chests of Lac-lake.

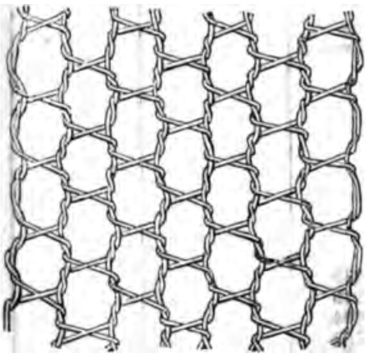
LACCIC ACID crystallizes, has a wine-yellow color, a sour taste, is soluble in water, alcohol, and ether. It was extracted from sticklac by Dr. John.

LACCINE is the portion of shellac which is insoluble in boiling alcohol. It is brown, brittle, translucid, consisting of agglomerated pellicles, more like a resin than any thing else. It is insoluble in ether and oils. It has not been applied to any use.

LACE MANUFACTURE. The pillow-made, or bone-lace, which formerly gave occupation to multitudes of women in their own houses, has, in the progress of mechanical invention, been nearly superseded by the bobbin-net lace, manufactured at first by hand-machines, as stockings are knit upon frames, but recently by the power of water or steam. This elegant texture possesses all the strength and regularity of the old Buckingham lace, and is far superior in these respects to the point-net and warp lace, which had preceded, and in some measure paved the way for it. Bobbin-net may be said to surpass every other branch of human industry in the complex ingenuity of its machinery; one of Fisher's spotting frames being as much beyond the most curious chronometer, in multiplicity of mechanical device, as that is beyond a common roasting-jack.

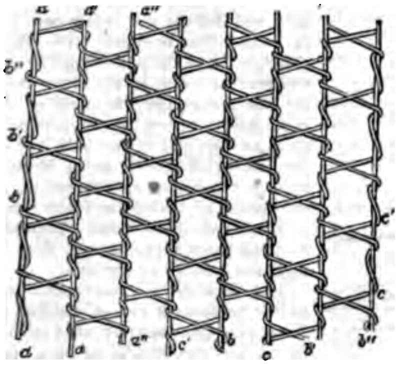
The threads in bobbin-net lace form, by their intertwisting and deccussation, regular hexagonal holes or meshes, of which the two opposite sides, the upper and under, are directed along the breadth of the piece, or at right angles to the selvage or border. *Fig.* 608 shows how, by the crossing and twisting of the threads, the regular six-sided mesh is produced, and that the texture results from the union of three separate sets of threads, of which one set proceeds downwards in serpentine lines, a second set proceeds from the left to the right, and a third from the right to the left, both in slanting directions. These oblique threads twist themselves round the vertical ones, and also cross each other betwixt them, in a peculiar manner, which may be readily understood by examining the representation. In comparing bobbin-net with a common web, the perpendicular threads in the figure, which are parallel to the border, may be regarded as the warp, and the two sets of slanting threads, as the weft.

608



These warp threads are extended up and down, in the original mounting of the piece, between a top and bottom horizontal roller or beam, of which one is called the warp beam, and the other the lace beam, because the warp and finished lace are wound upon them respectively. These straight warp threads receive their contortion from the tension of the weft threads twisted obliquely round them alternately to the right and the left hand. Were the warp threads so tightly drawn that they became inflexible, like fiddle-strings, then the lace would assume the appearance shown in *fig* 609; and although this condition does not really exist, it may serve to illustrate the structure of the web. The warp threads stand in the positions *a a*, *a' a'*, and *a'' a''*; the one half of the weft proceeds in the direction *b b*, *b' b'*, and *b'' b''*; and the second crosses the first by running in the direction *c c*, or *c' c'*, towards the opposite side of the fabric. If we pursue the path of a weft thread, we find it goes on till it reaches the outermost or last warp thread, which it twists about; not once, as with the others, but twice; and then returning towards the other border, proceeds in a reverse direction. It is by this double twist, and by the return of the weft threads, that the selvage is made.

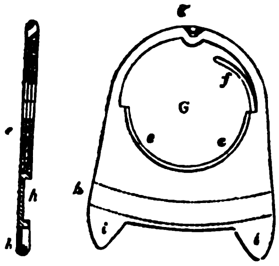
609



The ordinary material of bobbin-net is two cotton yarns, of from No. 180 to No. 250, twisted into one thread; but sometimes strongly twisted single yarn has been used. The beauty of the fabric depends upon the quality of the material, as well as the regularity and smallness of the meshes. The number of warp threads in a yard in breadth is from 600 to 900; which is equivalent to from 20 to 30 in an inch. The size of the holes cannot be exactly inferred from that circumstance, as it depends partly upon the oblique traction of the threads. The breadth of the pieces of bobbin-net varies from edgings of a quarter of an inch, to webs 12, or even 20 quarters, that is, 5 yards wide.

Bobbin-net lace is manufactured by means of very costly and complicated machines, called *frames*. The limits of this Dictionary will admit of an explanation of no more than the general principles of the manufacture. The threads for crossing and twisting round the warp, being previously gassed, that is, freed from loose fibres by singeing with gas, are wound round small pulleys, called bobbins, which are, with this view, deeply grooved in their periphery. *Figs.* 610, 611 exhibit the bobbin alone, and with its carriage.

611



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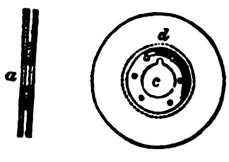
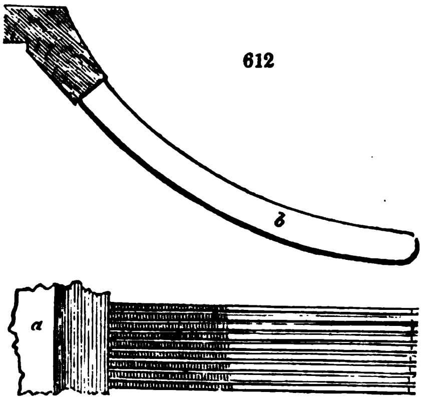


In the section of the bobbin *a*, *fig.* 610, the deep groove is shown in which the thread is wound. The bobbin consists of two thin discs of brass, cut out in a stamp-press, in the middle of each of which there is a hollow space *c*. These discs are riveted together, leaving an interval between their edge all round, in which the thread is coiled. The round hole in the centre, with the little notch at top, serves for spitting them upon a feathered rod, in order to be filled with thread by the rotation of that rod in a species of reel, called the bobbin-filling machine. Each of these bobbins (about double the size of the figure), is inserted into the vacant space G, of the carriage, *fig.* 611. This is a small iron frame (also double the size of the figure), which, at *e e*, embraces the grooved border of the bobbin, and by the pressure of the spring at *f*, prevents it from falling out. This spring serves likewise to apply sufficient friction to the bobbin, so as to prevent it from giving off its thread at *g* by its rotation, unless a certain small force of traction be employed upon the thread. The curvilinear groove *h h*, sunk in each face or side of the carriage, has the depth shown in the section at *h*. This groove corresponds to the interval between the teeth of the comb, or bars of the bolt, in which each carriage is placed, and has its movement. A portion of that bolt or comb is shown at *a*, *fig.* 612, in plan, and one bar of a circular bolt machine at *b*, in section. If we suppose two such combs or bolts placed with the ends of the teeth opposite each other, but a little apart, to let the warp threads be stretched, in one vertical plane, between their ends or tips, we shall have an idea of the skeleton of a bobbin-net machine. One of these two combs, in the double bolt machine, has an occasional lateral movement called *shogging*, equal to the interval of one tooth or bolt, by which, after it has received the bobbins, with their carriages, into its teeth, it can shift that interval to the one side, and thereby get into a position to return the bobbins, with their carriages, into the next series of interstices or gates, in the other bolt. By this means the whole series of carriages receives successive side steps to the right in one bolt, and to the left in the other, so as to perform a species of countermarch, in the course of which they are made to cross and twist round about the vertical warp threads, and thus to form the meshes of the net.

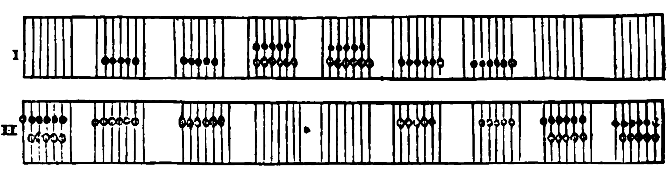
612



The number of movements required to form a row of meshes in the double tier machine, that is, in a frame with two combs or bars, and 2 rows of bobbins, is six; that is, the whole of the carriages (with their bobbins) pass from one bar or comb to the other six times, during which passages the different divisions of bobbin and warp threads change their relative positions 12 times.

This interchange or traversing of the carriages with their bobbins, which is the most difficult thing to explain, but at the same time the most essential principle of the lace-machine, may be tolerably well understood by a careful study of *fig.* 613, in which the simple line | represents the bolts or teeth, the sign ♦ the back line of carriages, and the sign ϕ the front line of carriages. H is the front comb or bolt bar, and I the back bolt bar. The former remains always fixed or stationary, to receive the carriages as they may be presented to it by the shogging of the latter. There must be always one odd carriage at the end; the rest being in pairs.

613



No. 1 represents the carriages in the front comb or bar, the odd carriage being at the left end. The back line of carriages is first moved on to the back bar I, the odd carriage, as seen in No. 1, having been left behind, there being no carriage opposite to drive it over to the other comb or bar. The carriages then stand as in No. 2. The bar I now shifts to the left, as shown in No. 3; the front carriages then go over into the back bar or comb, as is represented by No. 4. The bar I now shifts to the right, and gives the position No. 5. The front carriages are then driven over to the front bar, and leave the odd carriage on the back bar at the right end, for the same reason as before described, and the carriages stand as shown in No. 6. The bar I next shifts to the left, and the carriages stand as in No. 7 (the odd carriage being thereby on the back bar to the left.) The back carriages now come over to the front bar, and stand as in No. 8. The back bar or comb I shifts to the right as seen in No. 9, which completes the traverse. The whole carriages with their bobbins have now changed their position, as will be seen by comparing No. 9 with No. 1. The odd carriage, No. 1 ϕ has advanced one step to the right, and has become one of the front tier; one of the back tier or line ϕ has advanced one step to the left, and has become the odd carriage; and one of the front ones ϕ has gone over to the back line. The bobbins and carriages throughout the whole width of the machine have thus crossed each other's course, and completed the mesh of net.

The carriages with their bobbins are driven a certain way from the one comb to the other, by the pressure of two long bars (one for each) placed above the level of the comb, until they come into such a position that their projecting heels or catches *i i*, *fig.* 611, are moved off by two other long flat bars below, called the locker plates, and thereby carried completely over the interval between the two combs.

There are six different systems of bobbin-net machines. 1. Heathcoate's patent machine. 2. Brown's traverse warp. 3. Morley's straight bolt. 4. Clarke's pusher principle, single tier. 5. Leaver's machine, single tier. 6. Morley's circular bolt. All the others are mere variations in the construction of some of their parts. It is a remarkable fact, highly honorable to the mechanical judgment of Mr. Morley of Derby, that no machines except those upon his circular bolt principle, have been found capable of working successfully by mechanical power.

The circular bolt machine (comb with curved teeth) was used by Mr. Morley, for making narrow breadths or edgings of lace immediately after its first invention, and it has been regularly used by the trade for that purpose ever since, in consequence of the inventor having declined to secure the monopoly of it to himself by patent. At that time the locker bars for driving across the carriages had only one plate or blade. A machine so mounted is now called "the single locker circular bolt." In the year 1824, Mr. Morley added another plate to each of the locker bars, which was a great improvement on the machines for making plain net, but an obstruction to the making of narrow breadths upon them. This machine is now distinguished from the former by the term "double locker."*

A rack of lace, is a certain length of work counted perpendicularly, and contains 240 meshes or holes. Well-made lace has the meshes a little elongated in the direction of the selvage.

The term gauge, in the lace manufacture, means the number of gates, slits, or interstices, in one inch of the bolt-bar or comb; and corresponds therefore to the number of bobbins in an inch length of the double tier. Thus, when we say "gauge nine points," we mean that there are nine gates with nine bobbins in one inch of the comb or bolt-bar. Each of such bobbins with its carriage is therefore no more than one ninth of an inch thick. The common proportion or gauge up and down the machine is 16 holes in the inch for ten bobbins transversely. Circular bolt double tier machines can turn off by steam power fully 360 racks each day of 18 hours, with a relay of superintendents.

The number of new mechanical contrivances to which this branch of manufacture has given rise, is altogether unparalleled in any other department of the arts. Since Mr. Heathcote's first successful patent, in 1809, a great many other patents have been granted for making lace. In the year 1811, Mr. Morley, then of Nottingham, invented his straight bolt frame, more simple in construction, better combined, and more easy in its movements, than the preceding machines; but the modest inventor did not secure it, as he might have done, by patent. The pusher machine was invented in the same year, by Samuel Mart and James Clark, also of Nottingham. The following year is remarkable in the history of the lace trade, for the invention of the circular bolt machine, by Mr. Morley—a mechanism possessing all the advantages of his straight bolt machine, without its disadvantages.

Nearly at the same time Mr. John Leaver brought forward the lever machine, conjointly with one Turton, both of New Radford, near Nottingham. About the year 1817 or 1818, Mr. Heathcote applied the rotatory movemement to the circular bolt machine, and mounted a manufactory on that plan, by mechanical power, at Tiverton, after he and his partner, Mr. Boden, had been driven from Loughborough, in 1816, by the atrocious violence of the frame-destroying Luddites.

Such has been the progress of improvement and economy in this manufacture, that the cost of labor in making a *rack*, which was, twenty years ago, 3*s*. 6*d*., or 42 pence, is now not more than one penny. The prices of this beautiful fabric have fallen in an equally remarkable manner. At the former period, a 24 rack piece, five quarters broad, fetched 17*l*. sterling, in the wholesale market; the same is now sold for 7*s*.! The consequence is, that in lace decoration, the maid servant may be now more sumptuously arrayed than her mistress could afford to be twenty years ago.

LACKER, is a varnish, consisting chiefly of a solution of pale shellac in alcohol tinged with saffron, annotto, or other coloring matter. See VARNISH.

LACTIC ACID. (*Acide Lactique*, Fr.; *Milchsaüre*, Germ.) This acid was discovered by Scheele in buttermilk, where it exists most abundantly; but it is present also in fresh milk in small quantity, and communicates to it the property of reddening litmus. Lactic acid may be detected in all the fluids of the animal body; either free or saturated with alkaline matter.

Scheele obtained this acid by evaporating the sour whey of clotted milk to an eighth part of its bulk, saturating this remainder with slaked lime, in order to throw down the subphosphate of lime held in solution, filtering the liquor, diluting it with thrice its weight of water, and precipitating the lime circumspectly, by the gradual addition of oxalic acid.

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* By reading the above brief account of Bobbin-net, in connexion with the more detailed description of it in my COTTON MANUFACTURE OF GREAT BRITAIN, a tolerably clear conception of the nature of this intricate manufacture may be obtained.

He next filtered, evaporated to dryness on a water bath, and digested the residuum in strong alcohol, which dissolved the lactic acid, and left the sugar of milk. On evaporating off the alcohol, the acid was obtained. As thus procured, it requires to be purified by saturation with carbonate of lead (pure white lead), and precipitating the solution of this lactate with sulphate of zinc, not added in excess. Sulphate of lead falls, and the supernatant lactate of zinc being evaporated affords crystals, at first brown, but which become colorless on being dissolved and re-crystallized twice or thrice. If the sulphuric acid of the dissolved salt be thrown down by water of baryta, the liquid when filtered and evaporated yields a pure lactic acid, of a sirupy consistence, colorless and void of smell. It has a pungent acid taste, which it loses almost entirely when moderately diluted with water. It does not crystallize. Its salts, with the exception of those of magnesia and zinc, have a gummy appearance, and are very soluble in alcohol, unless they hold an excess of base. Lactic acid consists of 44·92 carbon; 6·55 hydrogen; 48·53 oxygen. It contains 9·92 per cent. of water. It has not hitherto been applied to any use in the arts, except by the Dutch in their old process of bleaching linen with sour milk.

LACTOMETER is the name of an instrument for estimating the quality of milk, called also a *Galactometer*, which see. The most convenient form of apparatus would be a series of glass tubes each about 1 inch in diameter, and 12 inches long, graduated through a space of 10 inches, to tenths of an inch, having a stop-cock at the bottom, and suspended upright in a frame. The average milk of the cow being poured in to the height of 10 inches, as soon as the cream has all separated at top, the thickness of its body may be measured by the scale; and then the skim milk may be run off below into a hydrometer glass, in order to determine its density, or relative richness in caseous matter.

LAKES. Under this title are comprised all those colors which consist of a vegetable dye, combined by precipitation with a white earthy basis, which is usually alumina. The general method of preparation is to add to the colored infusion a solution of common alum, or rather a solution of alum saturated with potash, especially when the infusion has been made with the aid of acids. At first only a slight precipitate falls, consisting of alumina and the coloring matter; but on adding potash, a copious precipitation ensues, of the alumina associated with the dye. When the dyes are not injured, but are rather brightened by alkalis, the above process is reversed; a decoction of the dye-stuff is made with an alkaline liquor, and when it is filtered, a solution of alum is poured into it. The third method is practicable only with substances having a great affinity for subsulphate of alumina; it consists in agitating recently precipitated alumina with the decoction of the dye.

Yellow lakes are made with a decoction of Persian or French berries, to which some potash or soda is added; into the mixture a solution of alum is to be poured as long as any precipitate falls. The precipitate must be filtered, washed, and formed into cakes, and dried. A lake may be made in the same way with quercitron, taking the precaution to purify the decoction of the dye-stuff with buttermilk or glue. After filtering the lake it may be brightened with a solution of tin. Annotto lake is formed by dissolving the dye-stuff in a weak alkaline ley, and adding alum water to the solution. Solution of tin gives this lake a lemon yellow cast; acids a reddish tint.

Red lakes.—The finest of these is *carmine.*

This beautiful pigment was accidentally discovered by a Franciscan monk at Pisa. He formed an extract of cochineal with salt of tartar, in order to employ it as a medicine, and obtained, on the addition of an acid to it, a fine red precipitate. Homberg published a process for preparing it, in 1656. Carmine is the coloring matter of cochineal, prepared by precipitation from a decoction of the drug. Its composition varies according to the mode of making it. The ordinary carmine is prepared with alum, and consists of *carminium* (see COCHINEAL), a little animal matter, alumina, and sulphuric acid. See CARMINE.

Carminated lake, called lake of Florence, Paris, or Vienna. For making this pigment, the liquor is usually employed which is decanted from the carmine process. Into this, newly precipitated alumina is put; the mixture is stirred, and heated a little, but not too much. Whenever the alumina has absorbed the color, the mixture is allowed to settle, and the liquor is drawn off.

Sometimes alum is dissolved in the decoction of cochineal, and potash is then added, to throw down the alumina in combination with the coloring matter; but in this way an indifferent pigment is obtained. Occasionally, solution of tin is added, to brighten the dye.

A lake may be obtained from kermes, in the same way as from cochineal; but now it is seldom had recourse to.

Brazil-wood lakes.—Brazil wood is to be boiled in a proper quantity of water for 15 minutes; then, alum and solution of tin being added, the liquor is to be filtered, and a solution of potash poured in as long as it occasions a precipitate. This is separated by the filter, washed in pure water, mixed with a little gum water, and made into cakes. Or, the Brazil wood may be boiled along with a little vinegar, the decoction filtered, alum and salt of tin added, and then potash-ley poured in to precipitate the lake. For 1 pound of Brazil wood, 30 to 40 pounds of water, and from 1½ to 2 pounds of alum, may be taken, in producing a deep red lake; or the same proportions with half a pound of solution of tin. If the potash be added in excess, the tint will become violet. Cream of tartar occasions a brownish cast.

Madder lake.—A fine lake may be obtained from madder, by washing it in cold water as long as it gives out color; then sprinkling some solution of tin over it, and setting it aside for some days. A gentle heat may also be applied. The red liquor must be then separated by the filter, and decomposed by the addition of carbonate of soda, when a fine red precipitate will be obtained. Or, the reddish brown coloring matter of a decoction of madder may be first separated by acetate of lead, and then the rose-red color with alum. Or, madder tied up in a bag is boiled in water; to the decoction, alum is added, and then potash. The precipitate should be washed with boiling water, till it ceases to tinge it yellow; and it is then to be dried.

The following process merits a preference:

Diffuse 2 pounds of ground madder in 4 quarts of water, and after a maceration of 10 minutes, strain and squeeze the grounds in a press. Repeat this maceration, &c. twice upon the same portion of madder. It will now have a fine rose color. It must then be mixed with 5 or 6 pounds of water and half a pound of bruised alum, and heated upon a water bath for 3 or 4 hours, with the addition of water, as it evaporates, after which the whole must be thrown upon a filter cloth. The liquor which passes is to be filtered through paper, and then precipitated by carbonate of potash. If the potash be added in three successive doses, three different lakes will be obtained, of successively diminishing beauty. The precipitates must be washed till the water comes off colorless.

Blue lakes are hardly ever prepared, as indigo, Prussian blue, cobalt blue, and ultramarine, answer every purpose of blue pigments.

Green lakes are made by a mixture of yellow lakes with blue pigments; but chrome yellows mixed with blues produce almost all the requisite shades of green.

LAMINABLE is said of a metal which may be extended by passing between steel or hardened (chilled) cast-iron rollers.

For a description of metal rolling presses, see IRON and MINT; and

For a table of the relative laminability of metals, see DUCTILITY.

LAMIUM ALBUM, or the dead nettle, is said by Leuchs to afford in its leaves a greenish-yellow dye. The L. purpureum dyes a reddish-gray with salt of tin, and a greenish tint with iron liquor.

LAMPS differ so much in principle, form, and construction, as to render their description impossible, as a general subject of manufacture. In fact, the operations of the lampist, like those of the blacksmith, cabinet-maker, cooper, coppersmith, tinman, turner, &c., belong to a treatise upon handicraft trades. I shall here, however, introduce a tabular view of the relative light and economy of the lamps most generally known.

Kind of Lamps.	Intensity of light during						Mean of 7 hours.	Consumption per hour in grammes.	Light from 100 parts of oil.
	1 hour	2 hours	3 hours	4 hours	5 hours	6 hours			
1. Mechanical lamp of Carcel - -							100	42	238
2. Fountain lamp, and a chimney with flat wick	100	98	98	97	96	96	125	11	113
3. Dome argand -	103	90	72	61	42	34	31	26·714	116
4. Sinumbra lamp -	102	95	83	81	78	66	56	37·145	150
5. Do. with fountain above - -	100	90	70	52	41	32	85	43	197
6. Do. with another beak - - -	100	97	95	92	89	86	41	18	227
7. Girard's hydrostatic lamp - - -	101	96	84	81	76	70	63·66	34·714	182
8. Thilorier's or Parker's hydrostatic lamp -	106	103	100	94	92	90	107·66	51·143	215

In the above table, for the purpose of comparing the successive degrees of intensity, 100 represents the mean intensity of light during the first hour. The quantity of oil consumed per hour is given in grammes, of 15½ grains each. The last column expresses the quantity of light produced with a like consumption of oil, which was in all cases 100 grammes. See CANDLES.

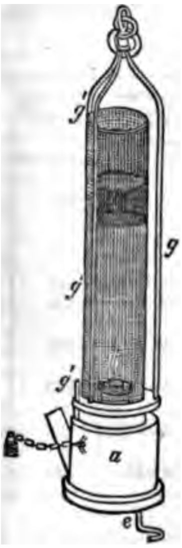
The following table of M. Peclet is perhaps more instructive :—

Nature of the light.	Intensity.	Consumption per hour in grammes.	Cost		Fat producing the same light.	Cost per hour.
			per kilogramme.	of light per hour.		
			francs.	*cents.*	*grammes.*	*cents.*
1. Mechanical lamp -	100	42	1·40	5·8	42	5·8
2. Flat-wick mechan. do.	12·05	11	1·40	1·5	88	12·3
3. Hemispherical dome lamp - - -	31·0	26·714	1·40	3·7	86·16	12·0
4. Sinumbra lamp -	85	43	1·40	6·0	50·58	7·0
5. Do. with a lateral fountain or vase - -	41	18	1·40	2·5	43·90	6·1
6. Do. with a fountain above - - -	90	43	1·40	6·0	47·77	6·6
7. Girard's hydrostatic lamp - - -	63·66	34·71	1·40	4·8	54·52	7·6
8. Thilorier's or Parker's lamp - - -	107·66	51·143	1·40	7·1	47·5	6·6
9. Candle, 6 in lb. -	10·66	8·51	1·40	1·2	70·35	9·8
10. Do. 8 in lb. -	8·74	7·51	1·40	1·0	85·92	12·0
11. Do. 6 with smaller wick - - -	7·50	7·42	2·40	1·7	98·93	23·7
12. Wax candle, 5 in lb.	13·61	8·71	7·60	5·7	64·04	48 6
13. Sperm candle, do.	14·40	8·92	7·60	5·8	61·94	47·8
14. Stearine candle, do.	14·30	9·35	6·00	5·5	65·24	37·1
15. Coal gas - - -	127	136 litres		5·0	107 litres	3·9
16. Oil gas - - -	127	136 do.		5·0	30	3·9

The light of the mechanical lamp is greatly over-rated relatively to that of gas. The cost of the former is at least 5 times greater than that of the latter, in London.

LAMP OF DAVY consists of a common oil lamp, surmounted with a covered cylinder of wire gauze, for transmitting light to the miner without endangering the kindling of the atmosphere of fire-damp which may surround him; because carbureted hydrogen, in passing through the meshes of the cylindric cover, gets cooled by the conducting power of the metallic gauze, below the point of its accension.

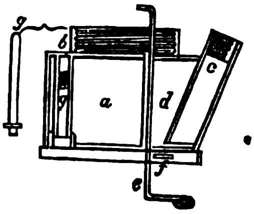
614



The apertures in the gauze should not be more than 1-20th of an inch square. Since the fire damp is not inflamed by ignited wire, the thickness of the wire is not of importance, but wire from 1-40th to 1-60th of an inch in diameter is the most convenient.

The cage or cylinder should be made by double joinings, the gauze being folded over in such a manner as to leave no apertures. When it is cylindrical, it should not be more than two inches in diameter; because in larger cylinders, the combustion of the fire-damp renders the top inconveniently hot; a double top is always a proper precaution, fixed ½ or ¾ of an inch above the first top. See *fig.* 614.

615



The gauze cylinder should be fastened to the lamp by a screw *b*, *fig.* 615, of four or five turns, and fitted to the screw by a tight ring. All joinings in the lamp should be made with hard solder; as the security depends upon the circumstance that no aperture exists in the apparatus larger than in the wire-gauze.

The parts of the lamp are,

1. The brass cistern *a*, *d*, *fig.* 615, which contains the oil. It is pierced at one side of the centre with a vertical narrow tube, nearly filled with a wire which is recurved above, at the level of the burner, to trim the wick, by acting on the lower end of the wire *e* with the fingers. It is called the safety-trimmer.

2. The rim *b* is the screw neck for fixing on the gauze cylinder, in which the wire-gauze cover is fixed, and which is fastened to the cistern by a screw fitted to *b*.

3. An aperture *c* for supplying oil. It is fitted with a screw or a cork, and communicates with the bottom of the cistern by a tube at *f*. A central aperture for the wick.

4. The wire-gauze cylinder, *fig.* 614, which should not have less than 625 apertures to the square inch.

5. The second top, ¾ of an inch above the first, surmounted by a brass or copper plate, to which the ring of suspension may be fixed. It is covered with a wire cap in the figure.

6. Four or six thick vertical wires, *g′ g′ g′ g′*, joining the cistern below with the top plate, and serving as protecting pillars round the cage. *g* is a screw-pin to fix the cover, so that it shall not become loosened by accident or carelessness. The oil-cistern *fig.* 615 is drawn upon a larger scale than *fig.* 614, to show its minuter parts.

When the wire-gauze safe-lamp is lighted and introduced into an atmosphere gradually mixed with fire-damp, the first effect of the fire-damp is to increase the length and size of the flame. When the inflammable gas forms so much as 1-12th of the volume of the air, the cylinder becomes filled with a feeble blue flame, while the flame of the wick appears burning brightly within the blue flame. The light of the wick augments till the fire-damp increases to 1-6th or 1-5th, when it is lost in the flame of the fire-damp, which in this case fills the cylinder with a pretty strong light. As long as any *explosive* mixture of gas exists in contact with the lamp, so long it will give light; and when it is extinguished, which happens whenever the foul air constitutes so much as 1-3d of the volume of the atmosphere, the air is no longer proper for respiration; for though animal life will continue where flame is extinguished, yet it is always with suffering. By fixing a coil of platinum wire above the wick, ignition may be maintained in the metal when the lamp itself is extinguished; and from this ignited wire the wick may be again rekindled, on carrying it into a less inflammable atmosphere.

"We have frequently used the lamps where the explosive mixture was so high as to heat the wire-gauze red-hot; but on examining a lamp which has been in constant use for three months, and occasionally subjected to this degree of heat, I cannot perceive that the gauze cylinder of iron wire is at all impaired. I have not, however, thought it prudent, in our present state of experience, to persist in using the lamps under such circumstances, because I have observed, that in such situations the particles of coal dust floating in the air, fire at the gas burning within the cylinder, and fly off in small luminous sparks. This appearance, I must confess, alarmed me in the first instance, but experience soon proved that it was not dangerous.

"Besides the facilities afforded by this invention to the working of coal-mines abounding in fire-damp, it has enabled the directors and superintendents to ascertain, with the utmost precision and expedition, both the presence, the quantity, and correct situation of the gas. Instead of creeping inch by inch with a candle, as is usual, along the galleries of a mine suspected to contain fire-damp, in order to ascertain its presence, we walk firmly on with the safe-lamps, and, with the utmost confidence, prove the actual state of the mine. By observing attentively the several appearances upon the flame of the lamp, in an examination of this kind, the cause of accidents which happened to the most experienced and cautious miners is completely developed; and this has hitherto been in a great measure matter of mere conjecture.

"It is not necessary that I should enlarge upon the national advantages which must necessarily result from an invention calculated to prolong our supply of mineral coal, because I think them obvious to every reflecting mind; but I cannot conclude without expressing my highest sentiments of admiration for those talents which have developed the properties, and controlled the power, of one of the most dangerous elements which human enterprise has hitherto had to encounter."—See Letter to Sir H. Davy, in Journal of Science, vol. i. p. 302, by John Buddle, Esq., generally and justly esteemed one of the most scientific coal-miners in the kingdom.

Mr. Buddle, in a letter dated 21st August, 1835, which is published in Dr. Davy's life of his brother Sir Humphrey, says:—

"In the evidence given in my last examination before a committee of the House of Commons, I stated that after nearly twenty years' experience of 'the Davy' with from 1000 to 1500 lamps in daily use, in all the variety of circumstances incidental to coal mining, without a single accident having happened which could be attributed to a defect in its principle, or even in the rules for its practical application, as laid down by Sir Humphrey—I maintained that 'the Davy' approximated perfection, as nearly as any instrument of human invention could be expected to do. We have ascertained distinctly that the late explosion did not happen in that part of the mine where the Davys were used. They were all found in a perfect state after the accident—many of them in the hands of the dead bodies of the sufferers."

LAMP-BLACK. See Black.

LAMPATES and LAMPIC ACID. When a spirit of wine lamp has its cotton wick surmounted with a spiral coil of platinum wire, after lighting it for a little, it may be blown out, without ceasing to burn the alcohol; for the coil continues ignited, and a current of hot vapor continues to rise, as long as the spirit lasts. This vapor was first condensed and examined by Professor Daniell, who called it lampic acid. It has a peculiar, strongly acid, burning taste, and a spec. grav. of 1·015. It possesses in an eminent degree the property of reducing certain metallic solutions; such as those of platinum, gold, and silver. The *lampates* may be prepared by saturating the above acid with the alkaline and earthy carbonates.

LAPIDARY, *Art of.* The art of the lapidary, or that of cutting, polishing, and engraving gems, was known to the ancients, many of whom have left admirable specimens of their skill. The Greeks were passionate lovers of rings and engraved stones; and the most parsimonious among the higher classes of the Cyrenians are said to have worn rings of the value of ten minæ (about 30*l.* of our money.) By far the greater part of the antique gems that have reached modern times, may be considered as so many models for forming the taste of the student of the fine arts, and for inspiring his mind with correct ideas of what is truly beautiful. With the cutting of the diamond, however, the ancients were unacquainted, and hence they wore it in its natural state. Even in the middle ages, this art was still unknown; for the four large diamonds which enrich the clasp of the imperial mantle of Charlemagne, as now preserved in Paris, are uncut, octahedral crystals. But the art of working diamonds was probably known in Hindostan and China, in very remote periods. After Louis de Berghen's discovery, in 1476, of polishing two diamonds by their mutual attrition, all the finest diamonds were sent to Holland to be cut and polished by the Dutch artists, who long retained a superiority, now no longer admitted by the lapidaries of London and Paris.

The operation of gem cutting is abridged by two methods; 1. by cleavage; 2. by cutting off slices with a fine wire, coated with diamond powder, and fixed in the stock of a hand-saw. Diamond is the only precious stone which is cut and polished with diamond powder, soaked with olive oil, upon a mill plate of very soft steel.

Oriental rubies, sapphires, and topazes, are cut with diamond powder soaked with olive oil, on a copper wheel. The facets thus formed are afterwards polished on another copper wheel, with tripoli, tempered with water.

Emeralds, hyacinths, amethysts, garnets, agates, and other softer stones, are cut at a lead wheel, with emery and water; and are polished on a tin wheel with tripoli and water, or, still better, on a zinc wheel, with putty of tin and water.

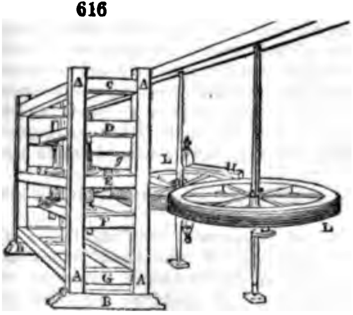
The more tender precious stones, and even the pastes, are cut on a mill-wheel of hard wood, with emery and water; and are polished with tripoli and water, on another wheel of hard wood.

Since the lapidary employs always the same tools, whatever be the stone which he cuts or polishes, and since the wheel discs alone vary, as also the substance he uses with them, we shall describe, first of all, his apparatus, and then the manipulations for diamond-cutting, which are applicable to every species of stone.

The lapidary's mill, or wheel, is shown in perspective in *fig.* 616. It consists of a strong frame made of oak carpentry, with tenon and mortised joints, bound together with strong bolts and screw nuts. Its form is a parallelopiped of from 8 to 9 feet long, by from 6 to 7 high; and about 2 feet broad. These dimensions are large enough to contain two cutting wheels alongside of each other, as represented in the figure.

Besides the two sole bars B B, we perceive in the breadth, 5 cross bars, C, D, E, F, G. The two extreme bars C and G, are a part of the frame-work, and serve to bind it. The two cross-bars D and F, carry each in the middle of their length, a piece of wood as thick as themselves, but only 4½ inches long (see *fig.* 617), joined solidly by mortises and tenons with that cross bar, as well as

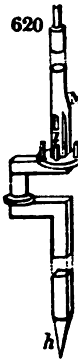
616



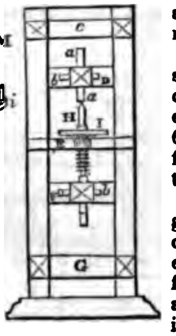
with the one placed opposite on the other parallel face. These two pieces are called *summers* (lintels); the one placed at D is the upper; the one at F, the lower.

In *fig.* 617 this face is shown inside, in order to explain how the mill wheel is placed and supported. The same letters point out the same objects, both in the preceding and the following figures.

620



617

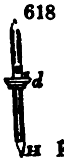


In each of these *summers* a square hole is cut out, exactly opposite to the other; in which are adjusted by friction, a square piece of oak *a*, *a*, *fig.* 617, whose extremities are perforated with a conical hole, which receives the two ends of the arbor H of the wheel I, and forms its socket. The square bar is adjusted at a convenient height, by a double wooden wedge *b b*.

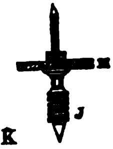
The cross bar in the middle E supports the table *c c*, a strong plank of oak. It is pierced with two large holes whose centres coincide with the centre of the conical holes hollowed out at the end of the square pins. These holes, of about 6 inches diameter each, are intended to let the arbor pass freely through, bearing its respective wheel. (See one of these holes at I, in *fig.* 621 below.)

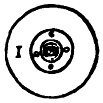
Each wheel is composed of an iron arbor H, *fig.* 618, of a grinding-wheel I, which differs in substance according to circumstances, as already stated, and of the pulley J, furnished with several grooves (see *fig.* 619), which has a square fit upon the arbor. The arbor carries a collet *d*, on which are 4 iron pegs or pins that enter into the wheel to fasten it.

618



619





The wheel plate, of which the ground plan is shown at K, is hollowed out towards its centre to half its thickness; when it is in its position on the arbor, as indicated in *fig.* 619, a washer or ferrule of wrought iron is put over it, and secured in its place by a double wedge. In *fig.* 619 the wheel-plate is represented in section, that the connexion of the whole parts may be seen.

A board *g* (see *fig.* 616 and *fig.* 624), about 7½ inches high, is fixed to the part of the frame opposite to the side at which the lapidary works, and it prevents the substances made use of in the cutting and polishing, from being thrown to a distance by the centrifugal force of the wheel-plate.

Behind this apparatus is mounted for each grinding-plate, a large wheel L (see *fig.* 616), similar to a cutler's, but placed horizontally. This wheel is grooved round its circumference to receive an endless cord or band, which passes round one of the grooves of the pulley J, fixed below the wheel-plate. Hence, on turning the fly-wheel L, the plate revolves with a velocity relative to the velocity communicated to the wheel L, and to the difference of diameter of the wheel L and the pulley J. Each wheel L, is mounted on an iron arbor, with a crank (see M, *fig.* 620.)

The lower pivot of that arbor *h* is conical, and turns in a socket fixed in the floor. The great wheel L rests on the collet *i*, furnished with its 4 iron pins, for securing the connexion. Above the wheel an iron washer is laid, and the whole is fixed by a double wedge, which enters into the mortise *l*, *fig.* 620.

621

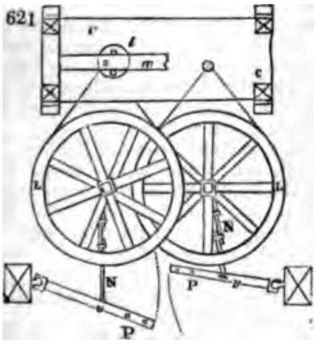
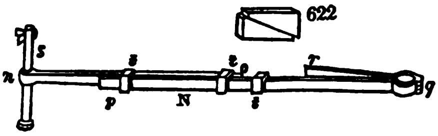


Fig. 621 exhibits a ground-plan view of all this assemblage of parts, to explain the structure of the machine. Every thing that stands above the upper *summer-bar* has been suppressed in this representation. Here we see the table *c c*; the upper *summer m*; the one wheel-plate *l*, the other having been removed to show that the endless cord does not cross; the two large wheels L L, present in each machine, the crank bar N, seen separate in *fig.* 622, which serves for turning the wheel L.

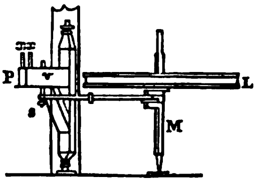
622



This bar is formed of 3 iron plates, *n*, *o*; *p*, *q*; and *q*, *r*; (*fig.* 622.) The first is bent round at the point *n*, to embrace the stud *s*; the second, *p q*, is of the same breadth and thickness as the first; and the third is adjusted to the latter with a hinge joint, at the point *q*, where they are both turned into a circular form, to embrace the crank M. When all these pieces are connected, they are fixed at the proper lengths by the buckles or square rings *t t t*, which embrace these pieces as is shown in *fig.* 621.

The stud *s*, seen in *fig.* 622, is fixed to the point *v* by a wedge key upon the arm P, represented separately, and in perspective in *fig.* 623. The laborer seizing the two upright pegs or handles *x x*, by the alternate forward and backward motion of his arm, he communicates the same motion to the crank rod, which transmits it to the crank of the arbor M, and impresses on that arbor, and the wheel which it bears, a rotatory movement.

623



624

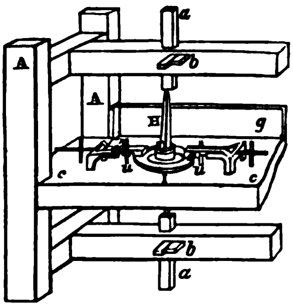


Fig. 624 shows piece-meal and in perspective, a part of the lapidary's wheel-mill. There we see the table *c c*, the grind-plate I, whose axis is kept in a vertical position by the two square plugs *a a*, fixed into the two *summers* by the wedges *b b*. On the two sides of the wheel-plate we perceive an important instrument called a *dial*, which serves to hold the stone during the cutting and polishing. This instrument has received lately important ameliorations, to be described in *fig.* 625. The lapidary holds this instrument in his hand, he rests it upon the iron pins *u u* fixed in the table, lest he should be affected by the velocity of the revolving wheel-plate. He loads it sometimes with weights *e*, *e*, to make it take better hold of the grinding plate.

One of the most expert lapidaries of Geneva works by means of the following improved mechanism, of his own invention, whereby he cuts and polishes the facets with extreme regularity, converting it into a true dial.

625

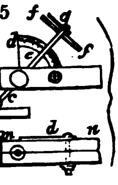


Fig. 625 shows this improvement. Each of the two jaws bears a large conchoidal cavity, into which is fitted a brass ball, which carries on its upper part a tube *e*, to whose extremity is fixed a dial-plate *f f*, engraved with several concentric circles, divided into equal parts, like the toothed-wheel cutting engine-plate, according to the number of facets to be placed in each cutting range. The tube receives with moderate friction the handle of the cement rod, which is fixed at the proper point by a thumb-screw, not shown in the figure, being concealed by the vertical limb *d*, about to be described.

A needle or index *g*, placed with a square fit on the tail of the cement rod, marks by its point the divisions on the dial plate *f f*. On the side *m n* of the jaw A, there is fixed by two screws, a limb *d*, forming a quadrant whose centre is supposed to be at the centre of the ball. This quadrant is divided as usual into 90 degrees, whose highest point is marked 0, and the lowest would mark about 70; for the remainder of the arc down to 90 is concealed by the jaw. The two graduated plates are used as follows:—

When the cement rod conceals zero or 0 of the limb, it is then vertical, and serves to cut the table of the brilliant; or the point opposite to it, and parallel to the table. On making it slope a little, 5 degrees for example, all the facets will now lie in the same zone, provided that the inclination be not allowed to vary. On turning round the cement rod the index *g* marks the divisions, so that by operating on the circle with 16 divisions, stopping for some time at each, 16 facets will have been formed, of perfect equality, and at equal distances, as soon as the revolution is completed.

Diamonds are cut at the present day in only two modes; into a rose diamond, and a brilliant. We shall therefore confine our attention to these two forms.

The rose diamond is flat beneath, like all weak stones, while the upper face rises into a dome, and is cut into facets. Most usually six facets are put on the central region, which are in the form of triangles, and unite at their summits; their bases abut upon another range of triangles, which being set in an inverse position to the preceding, present their bases to them, while their summits terminate at the sharp margin of the stone. The latter triangles leave spaces between them which are likewise cut each into two facets. By this distribution the rose diamond is cut into 24 facets; the surface of the diamond being divided into two portions, of which the upper is called the crown, and that forming the contour, beneath the former, is called *dentelle* (lace) by the French artists.

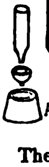
According to Mr. Jeffries, in his Treatise on Diamonds, the regular rose diamond is formed by inscribing a regular octagon in the centre of the table side of the stone, and bordering it by eight right-angled triangles, the bases of which correspond with the sides of the octagon; beyond these is a chain of 8 trapeziums, and another of 16 triangles. The collet side also consists of a minute central octagon, from every angle of which proceeds a ray to the edge of the girdle, forming the whole surface into 8 trapeziums, each of which is again subdivided by a salient angle (whose apex touches the girdle) into one irregular pentagon and two triangles.

To fashion a rough diamond into a brilliant, the first step is to modify the faces of the original octahedron, so that the plane formed by the junction of the two pyramids shall be an exact square, and the axis of the crystal precisely twice the length of one of the sides of the square. The octahedron being thus rectified, a section is to be made parallel to the common base or *girdle*, so as to cut off 5 eighteenths of the whole height from the upper pyramid, and 1 eighteenth from the lower one. The superior and larger plane thus produced is called the *table*, and the inferior and smaller one is called the *collet*; in this state it is termed a *complete square table diamond*. To convert it into a brilliant, two triangular facets are placed on each side of the table, thus changing it from a square to an octagon; a lozenge-shaped facet is also placed at each of the four corners of the table, and another lozenge extending lengthwise along the whole of each side of the original square of the table, which with two triangular facets set on the base of each lozenge, completes the whole number of facets on the table side of the diamond; viz., 8 lozenges, and 24 triangles. On the collet side are formed 4 irregular pentagons, alternating with as many irregular lozenges radiating from the collet as a centre, and bordered by 16 triangular facets adjoining the girdle. The brilliant being thus completed, is set with the table side uppermost, and the collet side implanted in the cavity made to receive the diamond. The brilliant is always three times as thick as the rose diamond. In France, the thickness of the brilliant is set off into two unequal portions; one third is reserved for the upper part or table of the diamond, and the remaining two thirds for the lower part or collet (*culasse*). The table has eight planes, and its circumference is cut into facets, of which some are triangles, and others lozenges. The collet is also cut into facets called *pavillons*. It is of consequence that the pavillons lie in the same order as the upper facets, and that they correspond to each other, so that the symmetry be perfect, for otherwise the play of the light would be false.

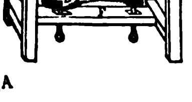
Although the rose-diamond projects bright beams of light in more extensive proportion often than the brilliant, yet the latter shows an incomparably greater play, from the difference of its cutting. In executing this, there are formed 32 faces of different figures, and inclined at different angles all round the table, on the upper side of the stone. On the *collet* (culasse) 24 other faces are made round a small table, which converts the culasse into a truncated pyramid. These 24 facets, like the 32 above, are differently inclined and present different figures. It is essential that the faces of the top and the bottom correspond together in sufficiently exact proportions to multiply the reflections and refractions, so as to produce the colors of the prismatic spectrum.

The other precious stones, as well as their artificial imitations, called *pastes*, are cut in the same fashion as the brilliant; the only difference consists in the matter constituting the wheel plates, and the grinding and polishing powders, as already stated.

626



627



In cutting the stones, they are mounted on the cement-rod B, *fig*. 626, whose stem is set upright in a socket placed in the middle of a sole piece at A, which receives the stem of the cement-rod. The head of the rod fills the cup of A. A melted alloy of tin and lead is poured into the head of the cement-rod, into the middle of which the stone is immediately plunged; and whenever the solder has become solid, a portion of it is pared off from the top of the diamond, to give the pyramidal form shown in the figure at B.

There is an instrument employed by the steel polishers for pieces of clock work, and by the manufacturers of watch-glasses for polishing their edges. It consists of a solid oaken table, *fig*. 627. The top is perforated with two holes, one for passing through the pulley and the arbor of the wheel-plate B, made either of lead or of hard wood, according to circumstances; and the other C for receiving the upper part of the arbor of the large pulley D. The upper pulley of the wheel plate is supported by an iron prop E, fixed to the table by two wooden screws. The inferior pivots of the two pieces are supported by screw-sockets, working in an iron screw-nut sunk into the summer-bar F. The legs of the table are made longer or shorter, according as the workman chooses to stand or sit at his employment. Emery with oil is used for grinding down, and tin-putty or colcothar for polishing. The workman lays the piece on the flat of the wheel-plate with one hand, and presses it down with a lump of cork, while he turns round the handle with the other hand.

The *Sapphire, Ruby, Oriental Amethyst, Oriental Emerald,* and *Oriental Topaz,* are gems next in value and hardness to diamond; and they all consist of nearly pure alumina or clay, with a minute portion of iron as the coloring matter. The following analyses show the affinity in composition of the most precious bodies with others in little relative estimation.

	Sapphire.	Corundum Stone.	Emery.
Alumina or clay -	98·5	89·50	86·0
Silica - - -	0·0	5·50	3·0
Oxyde of iron - -	1·0	1·25	4·0
Lime - - -	0·5	0·00	0·0
	100·0	96·25	93·0

Salamstone is a variety which consists of small transparent crystals, generally six-sided prisms, of pale reddish and bluish colors. The corundum of Battagammana is frequently found in large six-sided prisms: it is commonly of a brown color, whence it is called by the natives *curundu gallé*, cinnamon stone. The hair-brown and reddish-brown crystals are called adamantine spar. Sapphire and salamstone are chiefly met with in secondary repositories, as in the sand of rivers, &c., accompanied by crystals and grains of octahedral iron-ore and of several species of gems. Corundum is found in imbedded crystals in a rock, consisting of indianite. Adamantine spar occurs in a sort of granite.

The finest varieties of sapphire come from Pegu, where they occur in the Capelan mountains near Syrian. Some have been found also at Hohenstein in Saxony, Bilin in Bohemia, Puy in France, and in several other countries. The red variety, the ruby, is most highly valued. Its color is between a bright scarlet and crimson. A perfect ruby above 3½ carats is more valuable than a diamond of the same weight. If it weigh 1 carat, it is worth 10 guineas; 2 carats, 40 guineas; 3 carats, 150 guineas; 6 carats, above 1000 guineas. A deep colored ruby, exceeding 20 carats in weight, is generally called a carbuncle; of which 108 were said to be in the throne of the Great Mogul, weighing from 100 to 200 carats each; but this statement is probably incorrect. The largest oriental ruby known to be in the world was brought from China to Prince Gargarin, governor of Siberia. It came afterwards into the possession of Prince Menzikoff, and constitutes now a jewel in the imperial crown of Russia.

A good blue sapphire of 10 carats is valued at 50 guineas. If it weighs 20 carats, its value is 200 guineas; but under 10 carats, the price may be estimated by multiplying the square of its weight in carats into half a guinea; thus, one of 4 carats would be worth $4^2 \times \frac{1}{2}$ G. $=$ 8 guineas. It has been said that the blue sapphire is superior in hardness to the red, but this is probably a mistake arising from confounding the corundum ruby with the spinelle ruby. A sapphire of a barbel blue color, weighing 6 carats, was disposed of in Paris by public sale for 70*l.* sterling; and another of an indigo blue, weighing 6 carats and 3 grains, brought 60*l.*; both of which sums much exceed what the preceding rule assigns, from which we may perceive how far fancy may go in such matters. The sapphire of Brazil is merely a blue tourmaline, as its specific gravity and inferior hardness show. White sapphires are sometimes so pure, that when properly cut and polished they have been passed for diamonds.

The yellow and green sapphires are much prized under the names of Oriental topaz and emerald. The specimens which exhibit all these colors associated in one stone are highly valued, as they prove the mineralogical identity of these varieties.

Besides these shades of color, sapphires often emit a beautiful play of colors, or *chatoiement*, when held in different positions relative to the eye or incident light; and some likewise present star-like radiations, whence they are called star-stones or *asterias;* sending forth 6 or even 12 rays, that change their place with the position of the stone. This property, so remarkable in certain blue sapphires, is not, however, peculiar to these gems. It seems to belong to transparent minerals which have a rhomboid for their nucleus, and arises from the combination of certain circumstances in their cutting and structure. Lapidaries often expose the light-blue variety of sapphire to the action of fire, in order to render it white and more brilliant; but with regard to those found at Expailly, in France, fire deepens their color.

3. *Chrysoberyl*, called by Haüy, Cymophane, and by others, Prismatic corundum, ranks next in hardness to sapphire, being 8·5 on the same scale of estimation. Its specific gravity is 3·754. It usually occurs in rounded pieces about the size of a pea, but it is also found crystallized in many forms, of which 8-sided prisms with 8-sided summits are perhaps the most frequent. Lustre vitreous, color asparagus green, passing into greenish-white and olive-green. It shows a bluish opalescence, a light undulating, as it were, in the stone, when viewed in certain directions; which property constitutes its chief attraction to the jeweller. When polished, it has been sometimes mistaken for a yellow diamond; and from its hardness and lustre is considerably valued. Good specimens of it are very rare. It has been found only in the alluvial deposites of rivers, along with other species of gems. Thus it occurs in Brazil, along with diamonds and prismatic topaz; also in Ceylon. Its constituents are alumina, 68·66; glucina, 16·00; silica, 6·00; protoxyde of iron, 4·7; oxyde of titanium, 2·66; moisture, 0·66; according to Seybert's analysis of a specimen from Brazil. It is difficultly but perfectly fusible before the blowpipe, with borax and salt of phosphorus. In composition it differs entirely from sapphire, or the rhombohedral corundum.

4. *Spinelle Ruby*, called Dodecahedral corundum, by some mineralogists, and Balas ruby, by lapidaries. Its hardness is 8. Specific gravity, 3·523. Its fundamental form is the hexahedron, but it occurs crystallized in many secondary forms: octahedrons, tetrahedrons, and rhombohedrons. Fracture, conchoidal; lustre, vitreous; color, red, passing into blue and green, yellow, brown, and black; and sometimes it is nearly white. Red spinelle consists of alumina, 74·5; silica, 15·5; magnesia, 8·25; oxyde of iron, 1·5; lime, 0·75. Vauquelin discovered 6·18 *per cent.* of chromic acid in the red spinelle. The red varieties exposed to heat become black and opaque; on cooling, they appear first green, then almost colorless, but at last resume their red color. *Pleonaste* is a variety which yields a deep green globule with borax.

Crystals of spinelle from Ceylon have been observed imbedded in limestone, mixed with mica, or in rocks containing adularia, which seem to have belonged to a primitive district. Other varieties like the pleonaste occur in the drusy cavities of rocks ejected by Vesuvius. Crystals of it are often found in diluvial and alluvial sand and gravel, along with true sapphires, pyramidal zircon, and other gems; as also with octahedral iron ore, in Ceylon. Blue and pearl-gray varieties occur in Südermannland, in Sweden, imbedded in granular limestone. Pleonaste is met with also in the diluvial sands of Ceylon. Clear and finely colored specimens of spinelle are highly prized as ornamental stones. When the weight of a good spinelle exceeds 4 carats, it is said to be valued at half the price of a diamond of the same weight. M. Brard has seen one at Paris which weighed 215 grains.

5. *Zircon* or *Hyacinth*. Its fundamental form is an isosceles 4-sided pyramid; and the secondary forms have all a pyramidal character. Fracture, conchoidal, uneven; lustre, more or less perfectly adamantine; colors, red, brown, yellow, gray, green, white; which, with the exception of some red tints, are not bright. Hardness, 7·5. Specific gravity, 4·5. Zircon and hyacinth consist, according to Klaproth, of almost exactly the same constituents; namely, zirconia, 70; silica, 25; oxyde of iron, 5. In the white zirconia there is less iron and more silica. Before the blowpipe the hyacinth loses its color, but does not melt. The brighter zircons are often worked up into a *brilliant* form, for ornamenting watch cases. As a gem, hyacinth has no high value. It has been often confounded with other stones, but its very great specific gravity makes it to be readily recognised.

6. *Topaz*. The fundamental form is a scalene 4-sided pyramid; but the secondary forms have a prismatic character; and are frequently observed in oblique 4-sided prisms, acuminated by 4 planes. The lateral planes of the prism are longitudinally striated. Fracture, conchoidal, uneven; lustre, vitreous; colors, white, yellow, green, blue; generally of pale shades. Hardness, 8; specific gravity, 3·5. Prismatic topaz consists, according to Berzelius, of alumina, 57·45; silica, 34·24; fluoric acid, 7·75. In a strong heat the faces of crystallization, but not those of cleavage, are covered with small blisters, which however immediately crack. With borax, it melts slowly into a transparent glass. Its powder colors the tincture of violets green. Those crystals which possess different faces of crystallization on opposite ends, acquire the opposite electricities on being heated. By friction, it acquires positive electricity.

Most perfect crystals of topaz have been found in Siberia, of green, blue, and white colors, along with beryl, in the Uralian and Altai mountains, as also in Kamschatka; in Brazil, where they generally occur in loose crystals, and pebble forms of bright yellow colors; and in Mucla, in Asia Minor, in pale straw-yellow regular crystals. They are also met with in the granitic detritus of Cairngorm, in Aberdeenshire. The blue varieties are absurdly called *oriental aquamarine*, by lapidaries. If exposed to heat, the Saxon topaz loses its color and becomes white; the deep yellow Brazilian varieties assume a pale pink hue; and are then sometimes mistaken for spinelle, to which, however, they are somewhat inferior in hardness. Topaz is also distinguishable by its double refractive property. Tavernier mentions a topaz, in the possession of the Great Mogul, which weighed 157 carats, and cost 20,000*l.* sterling. There is a specimen in the museum of natural history at Paris which weighs 4 ounces 2 gros.

Topazes are not scarce enough to be much valued by the lapidary.

7. *Emerald* and *Beryl* are described in their alphabetical places. Emerald loses its lustre by candle-light; but as it appears to most advantage when in the company of diamonds, it is frequently surrounded with brilliants, and occasionally with pearls. Beryl is the aquamarine of the jewellers, and has very little estimation among lapidaries.

8. *Garnet.* See this stone in its alphabetical place.

9. *Chrysolite*, called *Peridot*, by Haüy; probably the topaz of the ancients, as our topaz was their chrysolite. It is the softest of the precious stones, being scratched by quartz and the file. It refracts double.

10. *Quartz*, including, as sub-species, *Amethyst*, *Rock-crystal*, *Rose-quartz*, *Prase*, or *Chrysoprase*, and several varieties of calcedony, as *Cat's-eye*, *Plasma*, *Chrysoprase*, *Onyx*, *Sardonyx*, &c. Lustre, vitreous, inclining sometimes to resinous; colors, very various; fracture, conchoidal; hardness, 7; specific gravity, 2·69.

11. *Opal*, or uncleavable quartz. Fracture, conchoidal; lustre, vitreous or resinous; colors, white, yellow, red, brown, green, gray. Lively play of light; hardness, 5·5 to 6·5; specific gravity, 2·091. It occurs in small kidney-shaped and stalactitic shapes, and large tuberose concretions. The phenomena of the play of colors in precious opal has not been satisfactorily explained. It seems to be connected with the regular structure of the mineral. Hydrophane, or oculis mundi, is a variety of opal without transparency, but acquiring it when immersed in water, or in any transparent fluid. Precious opal was found by Klaproth to consist of silica, 90; water, 10; which is a very curious combination. Hungary has been long the only locality of precious opal, where it occurs near Caschau, along with common and semi-opal, in a kind of porphyry. Fine varieties have, however, been lately discovered in the Faroe islands; and most beautiful ones, sometimes quite transparent, near Gracias a Dios, in the province of Honduras, America. The red and yellow bright colored varieties of fire-opal are found near Zimapan, in Mexico. Precious opal, when fashioned for a gem, is generally cut with a convex surface; and if large, pure, and exhibiting a bright play of colors, is of considerable value. In modern times, fine opals of moderate bulk have been frequently sold at the price of diamonds of equal size: the Turks being particularly fond of them. The estimation in which opal was held by the ancients is hardly credible. They called it Paideros, or Child beautiful as love. Nonius, the Roman senator, preferred banishment to parting with his favorite opal, which was coveted by Mark Antony. Opal which appears quite red when held against the light, is called *girasol* by the French; a name also given to the sapphire or corundum asterias or star-stone.

12. *Turquois* or *Calaite.* Mineral turquois occurs massive; fine-grained, impalpable; fracture, conchoidal; color, between a blue and a green, soft, and rather bright; opaque; hardness, 6; spec. grav., 2·83 to 3·0. Its constituents are alumina, 73; oxyde of copper, 4·5; oxyde of iron, 4; water, 18; according to Dr. John. But by Berzelius, it consists of phosphate of alumina and lime, silica, oxydes of copper, and iron, with a little water. It has been found only in the neighborhood of Nichabour in the Khorassan, in Persia; and is very highly prized as an ornamental stone in that country. There is a totally different kind of turquois, called *bone turquois*, which seems to be phosphate of lime colored with oxyde of copper. When the oriental stone is cut and polished, it forms a pleasing gem of inferior value. *Malachite*, or mountain green, a compact carbonate of copper, has been substituted sometimes for turquois, but their shades are different. Malachite yields a green streak, and turquois a white one.

13. *Lapis lazuli* is of little value, on account of its softness.

LEAD (*Plomb*, Fr.; *Blei*, Germ.). This is one of the metals most anciently known, being mentioned in the books of Moses. It has a gray-blue color, with a bright metallic lustre when newly cut, but it becomes soon tarnished and earthy looking in the air. Its texture is close, without perceptible cleavage or appearance of structure; the specific gravity of common lead is 11·352; but of the pure metal, from 11·38 to 11·44. It is very malleable and ductile, but soft and destitute of elasticity; fusible at 612° Fahr., by Crighton, at 634° by Kupfer, and crystallizable on cooling, into octahedrons implanted into each other so as to form an assemblage of four-sided pyramids.

There are four oxydes of lead. 1. The suboxyde, of a grayish-blue color, which forms a kind of crust upon a plate of lead long exposed to the air. It is procured in a perfect state by calcining oxalate of lead in a retort; the dark gray powder which remains, is the pure suboxyde. 2. The protoxyde is obtained by exposing melted lead to the atmosphere, or, more readily, by expelling the acid from the nitrate of lead by heat in a platinum crucible. It is yellow, and was at one time prepared as a pigment by calcining lead; but is now superseded by the chromate of this metal. Litharge is merely this oxyde in the form of small spangles, from having undergone fusion; it is more or less contaminated with iron, copper, and sometimes a little silver. It contains likewise some carbonic acid. The above oxyde consists of 104 of metal, and 8 of oxygen, its prime equivalent being 112, upon the hydrogen scale; and it is the base of all the salts of lead. 3. The plumbeous suroxyde of Berzelius, the sesquioxyde of some British chemists, is the well-known pigment called RED LEAD or *minium*. It consists of 100 parts of metal and 10 of oxygen. 4. The plumbic suroxyde of Berzelius, or the peroxyde of the British chemists, is obtained by putting red lead in chlorine water, or in dilute nitric acid. It is of a dark brown, almost black color, which gives out oxygen when heated, and becomes yellow oxyde. It kindles sulphur when triturated with it. This oxyde is used by the analytical chemist to separate, by condensation, the sulphurous acid existing in a gaseous mixture.

Among the ores of lead some have a metallic aspect; are black in substance, as well as when pulverized; others have a stony appearance, and are variously colored, with usually a vitreous or greasy lustre. The specific gravity of the latter ores is always less than 5. The whole of them, excepting the chloride, become more or less speedily black, with sulphureted hydrogen or with hydrosulphurets; and are easily reduced to the metallic state upon charcoal, with a flux of carbonate of soda, after they have been properly roasted. They diffuse a whitish or yellowish powder over the charcoal, which, according to the manner in which the flame of the blowpipe is directed upon it, becomes yellow or red; thus indicating the two characteristic colors of the oxydes of lead.

We shall not enter here into the controversy concerning the existence of native lead, which has been handled at length by M. Brongniart in the *Dictionnaire des Sciences Naturelles*, article *Plomb, Mineralogie.*

The lead ores most interesting to the arts are:—

1. *Galena*, sulphuret of lead. This ore has the metallic lustre of lead with a crystalline structure derivable from the cube. When heated cautiously at the blowpipe it is decomposed, the sulphur flies off, and the lead is left alone in fusion; but if the heat be continued, the colored surface of the charcoal indicates the conversion of the lead into its oxydes. Galena is a compound of lead and sulphur, in equivalent proportions, and therefore consists, in 100 parts, of 86⅔ of metal, and 13⅓ of sulphur, with which numbers the analysis of the galena of Clausthal by Westrumb exactly agrees. Its specific gravity, when pure, is 7·56. Its color is blackish gray, without any shade of red, and its powder is black, characters which distinguish it from *blende* or sulphuret of zinc. Its structure in mass is lamellar, passing sometimes into the fibrous or granular, and even compact. It is brittle. The *specular* galena, so called from its brightly polished aspect, is remarkable for forming the *slickensides* of Derbyshire—thin seams, which explode with a loud noise when accidentally scratched in the mine.

The argentiferous galena has in general all the external characters of pure galena. The proportions of silver vary from one fifth part of the whole, as at Tarnowitz, in Silesia, to three parts in ten thousand, as in the ore called by the German miners Weisgültigerz; but it must be observed, that whenever this lead ore contains above 5 per cent. of silver, several other metals are associated with it. The mean proportion of silver in galena, or that which makes it be considered practically as an argentiferous ore, because the silver may be profitably extracted, is about two parts in the thousand. See SILVER. The above rich silver ores were first observed in the Freyberg mines, called Himmelsfurst and Beschertgluck, combined with sulphuret of antimony; but they have been noticed since in the Hartz, in Mexico, and several other places.

The antimonial galena (*Bournonite*) exhales at the blowpipe the odor peculiar to antimony, and coats the charcoal with a powder partly white and partly red. It usually contains some arsenic.

2. The *Seleniuret of lead* resembles galena, but its tint is bluer. Its chemical characters are the only ones which can be depended on for distinguishing it. At the blowpipe it exhales a very perceptible smell of putrid radishes. Nitric acid liberates the selenium. When heated in a tube, oxyde of selenium of a carmine red rises along with selenic acid, white and deliquescent. The specific gravity of this ore varies from 6·8 to 7·69.

3. *Native minium* or *red lead* has an earthy aspect, of a lively and nearly pure red color, but sometimes inclining to orange. It occurs pulverulent, and also compact,

with a fracture somewhat lamellar. When heated at the blowpipe upon charcoal, it is readily reduced to metallic lead. Its specific gravity varies from 4·6 to 8·9. This ore is rare.

4. *Plomb-gomme.*—This lead ore, as singular in appearance as in composition, is of a dirty brownish or orange-yellow, and occurs under the form of globular or gum-like concretions. It has also the lustre and translucency of gum; with somewhat of a pearly aspect at times. It is harder than fluor spar. It consists of oxyde of lead, 40; alumina, 37; water, 18·8; foreign matters and loss, 4·06; in 100. Hitherto it has been found only at Huelgoet, near Poullaouen, in Brittany, covering with its tears or small concretions the ores of white lead and galena which compose the veins of that lead mine.

5. *White lead, carbonate of lead.*—This ore, in its purest state, is colorless and transparent like glass, with an adamantine lustre. It may be recognised by the following characters:—

Its specific gravity is from 6 to 6·7; it dissolves with more or less ease, and with effervescence, in nitric acid; becomes immediately black by the action of sulphureted hydrogen, and melts on charcoal before the blowpipe into a button of lead. According to Klaproth, the carbonate of Leadhills contains 82 parts of oxyde of lead, and 16 of carbonic acid, in 98 parts. This mineral is tender, scarcely scratches calc-spar, and breaks easily with a waved conchoidal fracture. It possesses the double refracting property in a very high degree; the double image being very visible on looking through the flat faces of the prismatic crystals. Its crystalline forms are very numerous, and are referrible to the octahedron, and the pyramidal prism.

6. *Vitreous lead*, or *sulphate of lead.*—This mineral closely resembles carbonate of lead; so that the external characters are inadequate to distinguish the two. But the following are sufficient. When pure, it has the same transparency and lustre. It does not effervesce with nitric acid; it is but feebly blackened by sulphureted hydrogen; it first decrepitates and then melts before the blowpipe into a transparent glass, which becomes milky as it cools. By the combined action of heat and charcoal, it passes first into a red pulverulent oxyde, and then into metallic lead. It consists, according to Klaproth, of 71 oxyde of lead, 25 sulphuric acid, 2 water, and 1 iron. That specimen was from Anglesea; the Wanlockhead mineral is free from iron. The prevailing form of crystallization is the rectangular octahedron, whose angles and edges are variously modified. The sulphato-carbonate, and sulphato tri-carbonate of lead, now called *Leadhillite*, are rare minerals which belong to this head.

7. *Phosphate of lead.*—This, like all the combinations of lead with an acid, exhibits no metallic lustre, but a variety of colors. Before the blowpipe upon charcoal, it melts into a globule externally crystalline, which, by a continuance of the heat, with the addition of iron and boracic acid, affords metallic lead. Its constituents are 80 oxyde of lead, 18 phosphoric acid, and 1·6 muriatic acid, according to Klaproth's analysis of the mineral from Wanlockhead. The constant presence of muriatic acid in the various specimens examined is a remarkable circumstance. The crystalline forms are derived from an obtuse rhomboid. Phosphate of lead is a little harder than white lead; it is easily scratched, and its powder is always gray. Its specific gravity is 6·9. It has a vitreous lustre, somewhat adamantine. Its lamellar texture is not very distinct; its fracture is wavy, and it is easily frangible. The phosphoric and arsenic acids being, according to M. Mitscherlich, isomorphous bodies, may replace each other in chemical combinations in every proportion, so that the phosphate of lead may include any proportion, from the smallest fraction of arsenic acid to the smallest fraction of phosphoric acid, thus graduating indefinitely into arseniate of lead. The yellowish variety indicates, for the most part, the presence of arsenic acid.

8. *Muriate of lead. Horn-lead*, or *murio-carbonate.*—This ore has a pale yellow color, is reducible to metallic lead by the agency of soda, and is not altered by the hydrosulphurets. At the blowpipe it melts first into a pale yellow transparent globule, with salt of phosphorus and oxyde of copper; and it manifests the presence of muriatic acid by a bluish flame. It is fragile, tender, softer than carbonate of lead, and is sometimes almost colorless, with an adamantine lustre. Spec. grav., 606. Its constituents, according to Berzelius, are lead, 25·84; oxyde of lead, 57·07; carbonate of lead, 6·25; chlorine, 8·84; silica, 1·46; water, 0·54; in 100 parts. The carbonate is an accidental ingredient, not being in equivalent proportion. Klaproth found chlorine, 13·67; lead, 39·98; oxyde of lead, 22·57; carbonate of lead, 23·78.

9. *Arseniate of lead.*—Its color of a pretty pure yellow, bordering slightly on the greenish, and its property of exhaling by the joint action of fire and charcoal a very distinct arsenical odor, are the only characters which distinguish this ore from the phosphate of lead. The form of the arseniate of lead, when it is crystallized, is a prism with six faces, of the same dimensions as that of phosphate of lead. When pure, it is reducible upon charcoal, before the blowpipe, into metallic lead, with the copious exhalation

of arsenical fumes; but only in part, and leaving a crystalline globule, when it contains any phosphate of lead. The arseniate of lead is tender, friable, sometimes even pulverulent, and of specific gravity 5·04. That of Johann-Georgenstadt consists, according to Rose, of oxyde of lead 77·5; arsenic acid 12·5; phosphoric acid 7·5, and muriatic acid 1·5.

10. *Red lead*, or *Chromate of lead.*—This mineral is too rare to require consideration in the present work.

11. *Plomb vauquelinite. Chromate of lead and copper.*

12. *Yellow lead. Molybdate of lead.*

13. *Tungstate of lead.*

Having thus enumerated the several species of lead ore, we may remark, that galena is the only one which occurs in sufficiently great masses to become the object of mining and metallurgy. This mineral is found in small quantity among the crystalline primitive rocks, as granite. It is however among the oldest talc-schists and clay slates, that it usually occurs. But galena is much more abundant among the transition rocks, being its principal locality, where it exists in interrupted beds, masses, and more rarely in veins. The blackish transition limestone is of all rocks that which contains most galena; as at Pierreville in Normandy; at Clausthal, Zellerfeldt, and most mines of the Harz; at Fahlun, in Sweden; in Derbyshire and Northumberland, &c. In the transition graywacke of the south of Scotland, the galena mines of Leadhills occur. The galena of the primitive formations contains more silver than that of the calcareous.

The principal lead mines at present worked in the world, are the following: 1. Poulläouen and Huelgöet near Carhaix in France, department of Finisterre, being veins of galena, which traverse a clay slate resting upon granite. They have been known for upwards of three centuries; the workings penetrate to a depth of upwards of 300 yards, and in 1816 furnished 500 tons of lead per annum, out of which 1034 pounds avoirdupois of silver were extracted. 2. At Villeforte and Viallaz, department of the Lozère, are galena mines said to produce 100 tons of lead *per annum*, with 400 kilogrammes of silver (880 lbs. avoird.). 3. At Pezey and Macot, to the east of Moutiers in Savoy, a galena mine exists in talc-schist, which has produced annually 200 tons of lead, and about 600 kilogrammes of silver (1320 lbs. avoird.). 4. The mine of Vedrin, near Namur in the Low Countries, is opened upon a vein of galena, traversing compact limestone of a transition district; it has furnished 200 tons of lead, from which 385 pounds avoird. of silver were extracted. 5. In Saxony the galena mines are so rich in silver as to make the lead be almost overlooked. They are enumerated under silver ores. 6. The lead mines of the Harz have been likewise considered as silver ores. 7. Those of Bleyberg in the Eifel are in the same predicament. 8. The galena mines of Bleyberg and Villach in Carinthia, in compact limestone. 9. In Bohemia, to the south-west of Prague. 10. The mines of Joachimsthal, and Bleystadt, on the southern slope of the Erzgebirge, produce argentiferous galena. 11. There are numerous lead mines in Spain, the most important being in the granite hills of Linarès, upon the southern slope of the Sierra Morena, and in the district of the small town of Canjagar. Sometimes enormous masses of galena are extracted from the mines of Linarès. There are also mines of galena in Catalonia, Grenada, Murcia, and Almeria, the ore of the last locality being generally poor in silver. 12. The lead mines of Sweden are very argentiferous, and worked chiefly with a view to the silver. 13. The lead mines of Daouria are numerous and rich, lying in a transition limestone, which rests on primitive rocks; their lead is neglected on account of the silver.

14. Of all the countries in the world, Great Britain is that which annually produces the greatest quantity of lead. According to M. Villefosse, in his *Richesse Minerale*, published in 1810, we had furnished every year 12,500 tons of lead, whilst all the rest of Europe taken together, did not produce so much; but from more recent documents, that estimate seems to have been too low. Mr. Taylor has rated the total product of the United Kingdom *per annum* at 31,900 tons, a quantity fully 2½ times greater than the estimate of Villefosse (see Conybeare and Phillips's Geology, p. 354). Mr. Taylor distributes this product among the different districts as follows:—

	Tons.
Wales, (Flintshire and Denbigshire) - - - - - - -	7,500
Scotland, (in transition graywacke) - - - - - - -	2,800
Durham, Cumberland, and Yorkshire, (in carboniferous lime) - -	19,000
Derbyshire, (probably in carboniferous lime) - - - -	1,000
Shropshire - - - - - - - - - - - - -	800
Devon and Cornwall, (transition and primitive rocks) - - -	800
Total - - - - - - - - - - - - -	31,900

We thus see that Cumberland, and the adjacent parts of the counties of Durham and

York, furnish of themselves nearly three fifths of the total product. Derbyshire was formerly much more productive. In Cornwall and Devonshire, the lead ore is found in veins in *killas*, a clay-slate passing into graywacke. In North Wales and the adjacent counties, as well as in Cumberland and Derbyshire, the lead occurs in the carboniferous limestone.

The English lead-miners distinguish three different kinds of deposites of lead ore; *rake-veins*, *pipe-veins*, and *flat-veins*. The English word vein corresponds to the French term *filon;* but miners make use of it indifferently in England and France, to indicate all the deposites of this ore, adding an epithet to distinguish the different forms; thus, *rake veins* are true veins in the geological acceptation of the word vein; *pipe-veins* are masses usually very narrow, and of oblong shape, most frequently parallel to the plane of the rocky strata; and *flat-veins* are small beds of ores interposed in the middle of these strata.

Rake-veins are the most common form in which lead ore occurs in Cumberland. They are in general narrower in the sandstone which covers the limestone, than in the calcareous beds. A thickness of less than a foot in the former, becomes suddenly 3 or 4 feet in the latter; in the rich vein of Hudgillburn, the thickness is 17 feet in the *Great limestone*, while it does not exceed 3 feet in the overlying *Watersill* or sandstone. This influence exercised on the veins by the nature of the enclosing rock, is instructive; it determines at the same time almost uniformly their richness in lead ore, an observation similar to what has been made in other countries, especially in the veins of Kongsburg in Norway. The Cumberland veins are constantly richer, the more powerful they are, in the portions which traverse the calcareous rocks, than in the beds of sandstone, and more particularly the schistose rocks. It is rare in the rock called *plate* (a solid slaty clay) for the vein to include any ore; it is commonly filled with a species of potter's earth. The upper calcareous beds are also in general more productive than the lower ones. In most of these mines, the veins were not worked till lately below the fifth calcareous bed (the four-fathom limestone), which is 307 yards beneath the mill-stone grit; and as the first limestone stratum is 108 yards beneath it, it follows that the thickness of the part of the ground where the veins are rich in lead does not in general exceed 200 yards. It appears however that veins have been mined in the neighborhood of Alston Moor, downwards to the eleventh calcareous stratum, or Tyne bottom limestone, which is 418 yards under the millstone-grit of the coal formation, immediately above the whin-sill; and that they have been followed above the first limestone stratum, as high as the grindstone sill, which is only 83 yards below the same stratum of mill-stone grit; so that in the total thickness of the plumbiferous formation there is more than 336 yards. It has been asserted that lead veins have been traced even further down, into the *Memerby* scar limestone; but they have not been mined.

The greatest enrichment of a vein takes place commonly in the points where its two sides, being not far asunder, belong to the same rock; and its impoverishment occurs when one side is calcareous and the other a schistose clay. The minerals which most frequently accompany the galena, are carbonate of lime, fluate of lime, sulphate of baryta, quartz, and pyrites.

The pipe-veins (*amas* in French) are seldom of great length; but some have a considerable width; their composition being somewhat similar to that of the *rake-veins*. They meet commonly in the neighborhood of the two systems, sometimes being in evident communication together; they are occasionally barren; but when a wide pipe-vein is metalliferous, it is said to be very productive.

The *flat veins*, or *strata veins*, seem to be nothing else than expansions of the matter of the vein between the planes of the strata; and contain the same ores as the veins in their vicinity. When they are metalliferous, they are worked along with the adjacent rake vein; and are productive to only a certain distance from that vein, unless they get enriched by crossing a rake vein. Some examples have been adduced of advantageous workings in *flat veins* in the *great limestone* of Cumberland, particularly in the mines of Coalcleugh and Nenthead. The *rake veins*, however, furnish the greater part of the lead which Cumberland and the adjacent counties send every year into the market. Mr. Forster gives a list of 165 lead mines, which have been formerly, or are now, worked in that district of the kingdom.

The metalliferous limestone occupies, in Derbyshire, a length of about 25 miles from north-west to south-east, under a very variable breadth, which towards the south, amounts to 25 miles. Castleton to the north, Buxton to the north-west, and Matlock to the south-east, lie nearly upon its limits. It is surrounded on almost all sides by the mill-stone grit which covers it, and which is, in its turn, covered by the coal strata. The nature of the rocks beneath the limestone is not known. In Cumberland the metalliferous limestone includes a bed of trap, designated under the name of *whinsill*. In Derbyshire the trap is much more abundant, and it is thrice interposed between the limestone. These two rocks constitute of themselves the whole mineral mass, through a thickness of about 550 yards, measuring from the millstone grit; only in the upper portion, that is, near the millstone grit, there is a pretty considerable thickness of argillo-calcareous schists.

Four great bodies or beds of limestone are distinguishable, which alternate with three masses of trap, called toadstone. The lead veins exist in the calcareous strata, but disappear at the limits of the toadstone. It has now been ascertained, however, that they recur in the limestone underneath.

Treatment of the Ores of Lead.

The mechanical operations performed upon the lead ores in Great Britain, to bring them to the degree of purity necessary for their metallurgic treatment, may be divided into three classes, whose objects are,—

1. *The sorting and cleansing of the ores;*
2. *The grinding;*
3. *The washing, properly so called.*

The apparatus subservient to the first objects are sieves, running buddles, and gratings. The large sieves employed in Derbyshire for sorting the ore at the mouth of the mine, into coarse and fine pieces, is a wire gauze of iron; its meshes are square, and an inch long in each side. There is a lighter sieve of wire gauze, similar to the preceding, for washing the mud from the ore, by agitating the fragments in a tub filled with water. But in Derbyshire, instead of using this sieve, the pieces of ore are sometimes merely stirred about with a shovel, in a trough filled with water. This is called a *standing buddle;* a most defective plan.

The *running buddle* serves at once to sort and cleanse the ore. It consists of a plane surface made of slabs or planks, very slightly inclined forwards, and provided behind and on the sides with upright ledges, the back one having a notch to admit a stream of water. The ore is merely stirred about with a shovel, and exposed on the slope to the stream. For this apparatus, formerly the only one used at the mines of Alston Moor, the following has been substituted, called the *grate.* It is a *grid,* composed of square bars of iron, an inch thick, by from 24 to 32 inches long, placed horizontally, and parallelly to each other, an inch apart. There is a wooden canal above the grate, which conducts a stream of water over its middle; and an inclined plane is set beneath it, which leads to a hemispherical basin, about 24 inches in diameter, for collecting the metallic powder washed out of the ore.

The apparatus subservient to grinding the ore are,—

1. The *bucker,* or beater, formed of a cast-iron plate, 3 inches square, with a socket in its upper surface, for receiving a wooden handle. In the neighborhood of Alston-Moor, crushing cylinders have been substituted for the beating bucker; but even now, in Derbyshire, buckers are generally employed for breaking the pieces of mixed ore, called *knock-stone-stuff.*

At the mines of this county, the *knocker's* workshop, or *striking floor,* is provided either with a strong stool, of a wall 3 feet high, beyond which there is a flat area 4 feet broad, and a little raised behind. On this area, bounded, except in front, by small walls, the ore to be bruised is placed. On the stool, or wall, a very hard stone slab, or cast-iron plate is laid, 7 feet long, 7 inches broad, and 1½ inches thick, called a *knock-stone.* The workmen seated before it, break the pieces of mixed ore, called *bowse* in Derbyshire, with the bucker.

Crushing machines are in general use at Alston Moor, to break the mingled ores, which they perform with great economy of time and labor. They have been employed there for nearly forty years.

This machine is composed of one pair of fluted cylinders, x x, *fig.* 628, and of two pairs of smooth cylinders z z, z' z', which serve altogether for crushing the ore. The two cylinders of each of the three pairs turn simultaneously in an inverse direction, by means of two toothed wheels, as at m, *fig.* 629, upon the shaft of every cylinder, which work by pairs in one another. The motion is given by a single water wheel, of which the circle a a a represents the outer circumference. One of the fluted cylinders is placed in the prolongation of the shaft of this wheel, which carries besides a cast-iron toothed wheel, geared with the toothed wheels e e, fixed upon the ends of two of the smooth cylinders. Above the fluted cylinders, there is a hopper, which discharges down between them, by means of a particular mechanism, the ore brought forwards by the wagons A. These wagons advance upon a railway, stop above the hopper, and empty their contents into it through a trap-hole, which opens outwardly in the middle of their bottom. Below the hopper there is a small bucket called a shoe, into which the ore is shaken down, and which throws it without ceasing upon the cylinders, in consequence of the constant jolts given it by a crank-rod i (*fig.* 629) attached to it, and moved by the teeth of the wheel m. The shoe is so regulated, that too much ore can never fall upon the cylinders, and obstruct their movement. A small stream of water is likewise led into the shoe, which spreads over the cylinders, and prevents them from growing hot. The ore, after passing between the fluted rollers,

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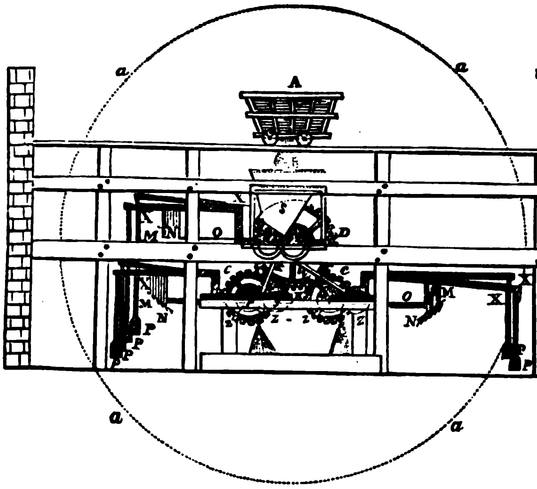

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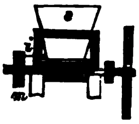


falls upon the inclined planes N, N, which turn it over to one or other of the pairs of smooth rolls.

These are the essential parts of this machine; they are made of iron, and the smooth ones are case-hardened, or *chilled*, by being cast in iron moulds. The gudgeons of both kinds move in brass bushes fixed upon iron supports *k*, made fast by bolts to the strong wood-work basis of the whole machine. Each of the horizontal bars has an oblong slot, at one of whose ends is solidly fixed one of the plummer-blocks or bearers of one of the cylinders *f*, and in the rest of the slot the plummer-block of the other cylinder *g* slides; a construction which permits the two cylinders to come into contact, or to recede to such a distance from each other, as circumstances may require. The moveable cylinder is approximated to the fixed one by means of the iron levers X X, which carry at their ends the weights P, and rest upon wedges M, which may be slidden upon the inclined plane N. These wedges then press the iron bar O, and make it approach the moveable cylinder by advancing the plummer block which supports its axis. When matters are so arranged, should a very large or hard piece present itself to one of the pairs of cylinders, one of the rollers would move away, and let the piece pass without doing injury to the mechanism.

Besides the three pairs of cylinders which constitute essentially each crushing machine, there is sometimes a fourth, which serves to crush the ore when not in large fragments, for example, the *chats* and *cuttings* (the moderately rich and poorer pieces), produced by the first sifting with the brake sieve, to be presently described. The cylinders composing that accessory piece, which, on account of their ordinary use, are called *chats-rollers*, are smooth, and similar to the rollers *z z*, and z′ z′. The one of them is usually placed upon the prolongation of the shaft of the water-wheel, of the side opposite to the principal machine; and the other, which is placed alongside, receives its motion from the first, by means of toothed wheel-work.

The *stamp mill* is employed in concurrence with the crushing cylinders. It serves particularly to pulverize those ores whose gangue is too hard to yield readily to the rollers, and also those which being already pulverized to a certain degree, require to be ground still more finely. The stamps employed in the neighborhood of Alston Moor are moved by water wheels. They are similar to those described under TIN.

Proper sifting or jigging apparatus.—The hand sieve made of iron wire meshes, of various sizes, is shaken with the two hands in a tub of water, the *ore vat*, being held sometimes horizontally, and at others in an inclined position. This sieve is now in general use only for the *cuttings* that have passed through the grating, and which though not poor enough to require finer grinding, are too poor for the brake sieve. When the workman has collected a sufficient quantity of these smaller pieces, he puts them in his round hand sieve, shakes it in the ore vat with much rapidity and a dexterous toss, till he has separated the very poor portions called *cuttings*, from the mingled parts called *chats*, as well as from the pure ore. He then removes the first two qualities, with a sheet-iron scraper called a *limp*, and he finds beneath them a certain portion of ore which he reckons to be pure.

The *brake sieve* is rectangular, as well as the cistern in which it is agitated. The meshes are made of strong iron wire, three eighths of an inch square. This sieve is suspended at the extremity of a forked lever, or brake, turning upon an axis by means of two upright arms about 5 feet long, which are pierced with holes for connecting them with bolts or pins, both to the sieve-frame and to the ends of the two branches of the lever. These two arms are made of wrought iron, but the lever is made of wood; as it receives the jolt. A child placed near its end, by the action of leaping, jerks it smartly up and down, so as to shake effectually the sieve suspended at the other extremity. Each jolt not only makes the fine parts pass through the meshes, but changes the relative position of those which remain on the wires, bringing the purer and heavier pieces eventually to the bottom. The mingled fragments of galena, and the stony substances called *chats* lie above them; while the poor and light pieces called *cuttings*, are at top. These are first scraped off by the *limp*, next the mixed lumps, or *chats*, and lastly the pure ore, which is carried to the *bing heap*. The *cuttings* are handed to a particular class of workmen, who by a new sifting, divide them into mere stones, or second *cuttings*, and into mixed ore analogous to *chats*.

The poor ore, called *chats*, is carried to a crushing machine, where it is bruised between two cylinders appropriated to this purpose under the name of *chats* rollers; after which it is sifted afresh. During the sifting many parcels of small ore and stony substances pass through the sieve, and accumulate at the bottom of the cistern. When it is two thirds filled, water is run slowly over it, and the sediment called *smitham* is taken out, and piled up in heaps. More being put into the tub, a child lifts up the *smitham*, and lays it on the sieve, which retains still on its meshes the layer of fine ore. The *sifter* now agitates in the water nearly as at first, from time to time removing with the *limp* the lighter matters as they come to the surface; which being fit for washing only in boxes, are called *buddler's offal*, and are thrown into the *buddle hole*.

Mr. Petherick, the manager of Lanescot and the Fowey Consol mines, has contrived an ingenious jigging machine, in which a series of 8 sieves are fixed in a stationary circular frame, connected with a plunger or piston working in a hollow cylinder, whereby a body of water is alternately forced up through the crushed ore in the sieves, and then left to descend. In this way of operating, the indiscriminate or premature passage of the finer pulverulent matter through the meshes is avoided, because a regulated stream of water is made to traverse the particles up and down. This mode has proved profitable in washing the copper ores of the above mentioned copper mines.

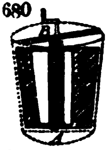
Proper washing apparatus.—For washing the ore after sifting it, the running buddle already described is employed, along with several chests or *buddles* of other kinds.

1. The *trunk buddle* is a species of German chest (see METALLURGY and TIN) composed of two parts; of a cistern or box into which a stream of water flows, and of a large tank with a smooth level bottom. The ore to be *trunked* being placed in the box, the workman furnished with a shovel bent up at its sides, agitates it, and removes from time to time the coarser portions; while the smaller are swept off by the water and deposited upon the level area.

2. The *stirring buddle*, or chest for freeing the *schlamms* or slimy stuff from clay, is analogous to the German chests, and consists of two parts; namely, 1. a trough which receives a stream of water through a plug hole, which is tempered at pleasure, to admit a greater or less current; 2. a settling tank with a horizontal bottom. The metallic *slime* being first floated in the water of the trough, then flows out and is deposited in the tank; the purest parts falling first near the beginning of the run.

3. The *nicking buddle* is analogous to the tables called *dormantes* or *jumelles* by the French miners. See METALLURGY. They have at their upper end a cross canal or spout, equal in length to the breadth of the table, with a plug hole in its middle for admitting the water. Alongside of this channel there is a slightly inclined plank, called *nicking board*, corresponding to the head of the *twin table*, and there is a nearly level plane below. The operation consists in spreading a thin layer of the *slime* upon the *nicking board*, and in running over its surface a slender sheet of water, which in its progress is subdivided into rills, which gradually carry off the muddy matters, and strew them over the lower flat surface of the tank, in the order of their density.

680



4. The *dolly tub* or rinsing bucket, *fig.* 630, has an upright shaft which bears the vane or *dolly* A B, turned by the winch handle. This apparatus serves to bring into a state of suspension in water, the fine ore, already nearly pure; the separation of the metallic particles from the earthy ones by repose, being promoted by the sides of the tub being struck frequently during the subsidence.

5. *Slime pits.*—In the several operations of cleansing ores from mud, in grinding, and washing, where a stream of water is used, it is impossible to prevent

some of the finely attenuated portions of the galena called *sludge*, floating in the water, from being carried off with it. *Slime pits* or *labyrinths*, called *buddle holes* in Derbyshire, are employed to collect that matter, by receiving the water to settle, at a little distance from the place of agitation.

These basins or reservoirs are about 20 feet in diameter, and from 24 to 40 inches deep. Here the suspended ore is deposited, and nothing but clear water is allowed to escape.

The workmen employed in the mechanical preparation of the ores, are paid, in Cumberland, by the piece, and not by day's wages. A certain quantity of crude ore is delivered to them, and their work is valued by the *bing*, a measure containing 14 cwts. of ore ready for smelting. The price varies according to the richness of the ore. Certain qualities are washed at the rate of two and sixpence, or three shillings the bing; while others are worth at least ten shillings. The richness of the ore varies from 2 to 20 bings of galena per *shift* of ore; the shift corresponding to 8 wagon loads.

1. The cleansing and sorting of the ores are well performed in Cumberland. These operations seem however to be inferior to the cleansing on the *grid steps, grilles à gradin*, of Saxony (See METALLURGY), an apparatus which in cleaning the ores, has the advantage of grouping them in lots of different qualities and dimensions.

2. The breaking or bruising by means of the *crushing machine*, is much more expeditious than the Derbyshire process by *buckers;* for the machine introduces not only great economy into the breaking operation, but it likewise diminishes considerably the loss of galena; for stamped ores may be often subjected to the action of the cylinders without waste, while a portion of them would have been lost with the water that runs from the stamp mill. The use of these rollers may therefore be considered as one of the happiest innovations hitherto made in the mechanical preparation of ores.

3. The *brake sieves* appear to be preferable to the hand ones.

4. The system of washing used in Cumberland differs essentially from that of Brittany. The slime pits are constructed with much less care than in France and Germany. They never present, as in these countries, those long windings backwards and forwards, whence they have been called labyrinths; probably because the last deposites, which are washed with profit in France and Germany, could not be so in Cumberland. There is reason to believe, however, that the introduction of *brake tables* (*tables à secousses*, see METALLURGY) would enable deposites to be saved, which at present run to waste in England.

5. From what we have now said about the system of washing, and the basins of deposite or settling cisterns, it may be inferred that the operation followed in Cumberland is more expeditious than that used in Brittany, but it furnishes less pure ores, and occasions more considerable waste; a fact sufficiently obvious, since the refuse stuff at Poullāouen is often resumed, and profitably subjected to a new preparation. We cannot however venture to blame this method, because in England, fuel being cheap, and labor dear, there may possibly be more advantage in smelting an ore somewhat impure, and in losing a little galena, than in multiplying the number of washing processes.

6. Lastly, the *dolly tub* ought to be adopted in all the establishments where the galena is mixed with much blende (sulphuret of zinc); for *schlich* (metallic slime) which appears very clean to the eye, gives off a considerable quantity of blende by means of the *dolly tub*. While the vane is rapidly whirled, the sludge is gradually let down into the revolving water, till the quantity is sufficiently great. Whenever the ore is thoroughly disseminated in the liquid, the dolly is withdrawn. The workmen then strike on the sides of the tub for a considerable time, with mallets or wooden billets, to make the slime fall fast to the bottom. The lighter portions, consisting almost entirely of refuse matter, fall only after the knocking has ceased: the water is now run away; then the very poor slime upon the top of the deposite is skimmed off, while the pure ore found at the bottom of the tub is lifted out, and laid on the *bingstead*. In this way the blende, which always accompanies galena in a greater or smaller quantity, is well separated.

Smelting of lead ores.—The lead ores of Derbyshire and the north of England were anciently smelted in very rude furnaces, or *boles*, urged by the natural force of the wind, and were therefore placed on the summits or western slopes of the highest hills. More recently these furnaces were replaced by blast hearths, resembling smiths' forges, but larger, and were blown by strong bellows, moved by men or water-wheels. The principal operation of smelting is at present always executed in Derbyshire in *reverberatory furnaces*, and at *Alston Moor* in furnaces similar to those known in France by the name of Scotch furnaces. Before entering into the detail of the founding processes, we shall give a description of the furnaces essential for both the smelting and accessory operations.

1. The reverberatory furnace called cupola, now exclusively used in Derbyshire for the smelting of lead ores, was imported thither from Wales, about the year 1747, by a company of Quakers. The first establishment in this country was built at Kalstedge, in the district of Ashover.

In the works where the construction of these furnaces is most improved, they are interiorly 8 feet long by 6 wide in the middle, and two feet high at the centre. The fire, placed at one of the extremities, is separated from the body of the furnace by a body of masonry, called the *fire-bridge*, which is two feet thick, leaving only from 14 to 18 inches between its upper surface and the vault. From this, the highest point, the vault gradually sinks towards the further end, where it stands only 6 inches above the sole. At this extremity of the furnace, there are two openings separated by a triangular prism of *fire-stone*, which lead to a flue, a foot and a half wide, and 10 feet long, which is recurved towards the top, and runs into an upright chimney 55 feet high. The above flue is covered with stone slabs, carefully jointed with fire-clay, which may be removed when the deposite formed under them (which is apt to melt) requires to be cleaned out. One of the sides of the furnace is called the laborers' side. It has a door for throwing coal upon the fire-grate, besides three small apertures each about 6 inches square. These are closed with moveable plates of cast iron, which are taken off when the working requires a freer circulation of air, or for the stirring up of the materials upon the hearth. On the opposite side, called the working side, there are five apertures; namely, three equal and opposite to those just described, shutting in like manner with cast iron plates, and beneath them two other openings, one of which is for running out the lead, and another for the scoriæ. The ash pit is also on this side, covered with a little water, and so disposed as that the grate-bars may be easily cleared from the cinder slag.

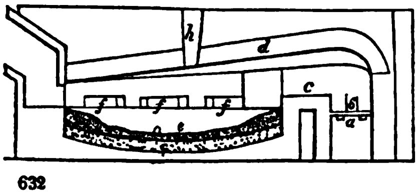
The hearth of the furnace is composed of the reverberatory furnace slags, to which a proper shape has been given by beating them with a strong iron rake, before their entire solidification. On the laborers' side, this hearth rises nearly to the surface of the three openings, and falls towards the working side, so as to be 18 inches below the middle aperture. In this point, the lowest of the furnace, there is a tap-hole, through which the lead is run off into a large iron boiler (lea-pan), placed in a recess left outside in the masonry. From that lowest point, the sole gradually rises in all directions, forming thus an inside basin, into which the lead runs down as it is smelted. At the usual level of the metal bath, there is on the working side, at the end furthest from the fire, an aperture for letting off the slag.

In the middle of the arched roof there is a small aperture, called the *crown-hole*, which is covered up during the working with a thick cast iron plate. Above this aperture a large wooden or iron hopper stands, leading beneath into an iron cylinder, through which the contents of the hopper may fall into the furnace when a trap or valve is opened.

2. *The roasting furnace.*—This was introduced about 30 years ago, in the neighborhood of Alston Moor, for roasting the ore intended to pass through the Scotch furnace, a process which greatly facilitates that operation. Since its first establishment it has successively received considerable improvements.

Figs. 631, 632, 633, represent the cupola furnace at the Marquess of Westminster's

631



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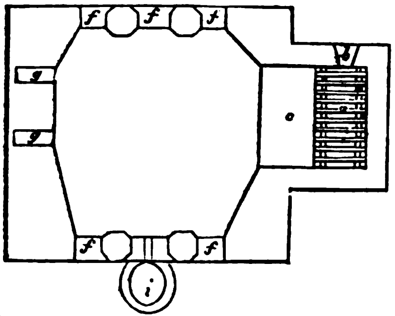
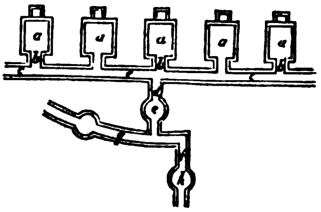


633



lead smelting works, two miles from Holywell. The hearth is hollowed out below the middle door of the furnace; it slopes from the back and ends towards this basin. The distance from the lowest point of this concavity up to the sill of the door, is usually 24 inches, but it is sometimes a little less, according to the quality of the ores to be smelted. This furnace has no hole for running off the slag, above the level of the top hole for the lead *i*, like the smelting furnace of Lea, near Matlock. A single chimney stalk serves for all the establishments; and receives all the flues of the various roasting and reducing furnaces. *Fig.* 633 gives an idea of the distribution of these flues. *a a a*, &c. are the furnaces; *b*, the flues, 18 inches square; these lead from each furnace to the principal conduit *c*, which is 5 feet deep by 2½ wide; *d* is 6 feet deep by 3 wide; *e* is a round chamber 15 feet in diameter; *f* is a conduit 7 feet high by 5 wide; *g* another, 6 feet high by 3 wide. The chimney at *h* has a diameter at bottom of 30 feet, a top of 12 feet, including the thickness of its sides, forming a truncated cone 100 feet high; whose base stands upon a hill a little way from the furnaces, and 62 feet above their level.

a, *figs.* 631, 632, is the grate; *b*, the door of the fire-place; *c*, the fire-bridge; *d*, the arched roof; *e*, the hearth; *f f f*, &c., the working doors; *g g*, flues running into one conduit, which leads to the subterranean condensing chamber, *e*, and thence to the general chimney; *h*, a hopper-shaped opening in the top of the furnace, for supplying it with materials.

This magnificent structure is not destined solely for the reduction of the ores, but for dissipating all the vapors which might prove noxious to the health of the work-people and to vegetation.

The ores smelted at Holywell are very refractory galenas, mixed with blende, calamine, pyrites, carbonate of lime, &c., but without any fluate of lime. They serve mutually as fluxes to one another. The coal is of inferior quality. The sole of each furnace is formed of slags obtained in the smelting, and they are all of one kind. In constructing it, 7 or 8 tons of these slags are first of all thrown upon the brick area of the hearth; are made to melt by a brisk fire, and in their stiffening state, as they cool, they permit the bottom to be sloped and hollowed into the desired shape. Four workmen, two at each side of the furnace, perform this task.

The ordinary charge of ore for one smelting operation is 20 cwts., and it is introduced through the hopper; see Copper, *fig.* 304. An assistant placed at the back doors spreads it equally over the whole hearth with a rake; the furnace being meanwhile heated only with the declining fire of the preceding operation. No regular fire is made during the first two hours, but a gentle heat merely is kept up by throwing one or two shovelfuls of small coal upon the grate from time to time. All the doors are closed, and the register-plate of the chimney is lowered.

The outer basin in front of the furnace is at this time filled with the lead derived from a former process, the metal being covered with slags. A rectangular slit above the tap hole is left open, and remains so during the whole time of the operation, unless the lead should rise in the interior basin above the level of that orifice; in which case a little mound must be raised before it.

The two doors in front furthest from the fire being soon opened, the head-smelter throws in through them, upon the sole of the furnace, the slags swimming upon the bath of lead, and a little while afterwards he opens the tap-hole, and runs off the metallic lead reduced from these slags. At the same time his assistant turns over the ore with his paddle, through the back doors. These being again closed, while the above two front doors are open, the smelter throws a shovelful of small coal or coke cinder upon the lead bath, and works the whole together, turning over the ore with the paddle or iron oar. About three quarters of an hour after the commencement of the operation, he throws back upon the sole of the hearth the fresh slags which then float upon the bath of the outer basin, and which are mixed with coaly matter. He next turns over these slags, as well as the ore with the paddle, and shuts all the doors. At this time the smelter runs off the lead into the pig-moulds.

The assistant now turns over the ore once more through the back doors. A little more than an hour after the operation began, a quantity of lead proceeding from the slag last remelted, is run off by the tap; being usually in such quantity as to fill one half of the outer basin. Both the workmen then turn over the ore with the paddles, at the several doors of the furnace. Its interior is at this time of a dull red heat; the roasting being carried on rather by the combustion of the sulphurous ingredients, than by the action of the small quantity of coal in the grate. The smelter, after shutting the front doors, with the exception of that next the fire-bridge, lifts off the fresh slags lying upon the surface of the outside bath, drains them, and throws them back into the furnace.

An hour and a half after the commencement, the lead begins to ooze out in small quantities from the ore; but little should be suffered to flow before two hours have expired. About this time the two workmen open all the doors, and turn over the ore, each at his own side of the furnace. An hour and three quarters after the beginning, there are few vapors in the furnace, its temperature being very moderate. No more lead is then seen to flow upon the sloping hearth. A little coal being thrown into the grate to raise the heat slightly, the workmen turn over the ore, and then close all the doors.

At the end of two hours, the *first fire* or roasting being completed, and the doors shut, the register is to be lifted a little, and coal thrown upon the grate to give the *second fire*, which lasts during 25 minutes. When the doors are now opened, the inside of the furnace is of a pretty vivid red, and the lead flows down from every side towards the inner basin. The smelter with his rake or paddle pushes the slags upon that basin back towards the upper part of the sole, and his assistant spreads them uniformly over the surface through the back doors. The smelter next throws in by his middle door, a few shovelfuls of quicklime upon the lead bath. The assistant meanwhile, for a quarter of an hour, works the ore and the slags together through the three back doors, and then spreads them out, while the smelter pushes the slags from the surface of the inner basin back to the upper parts of the sole. The doors being now left open for a little, while the interior remains in repose, the metallic lead, which had been pushed back with the slags, flows down into the basin. This occasional *cooling* of the furnace is thought to be necessary for the better separation of the products, especially of the slags, from the lead bath.

In a short time the workmen resume their rakes, and turn over the slags along with the ore. Three hours after the commencement, a little more fuel is put into the grate, merely to keep up a moderate heat of the furnace during the paddling. After three hours and ten minutes, the grate being charged with fuel for the *third fire*, the register is completely opened, the doors are all shut, and the furnace is left in this state for three quarters of an hour. In nearly four hours from the commencement, all the doors being opened, the assistant levels the surfaces with his rake, in order to favor the descent of any drops of lead; and then spreads the slags, which are pushed back towards him by the smelter. The latter now throws in a fresh quantity of lime, with the view not merely of covering the lead bath and preventing its oxydizement, but of rendering the slags less fluid.

Ten minutes after the third fire is completed, the smelter puts a new charge of fuel in the grate, and shuts the doors of the furnace to give it the *fourth fire*. In four hours and forty minutes from the commencement, this fire being finished, the doors are opened, the smelter pierces the tap hole to discharge the lead into the outer basin, and throws some quicklime upon the slags in the inner basin. He then pushes the slags thus *dried up* towards the upper part of the hearth, and his assistant rakes them out by the back doors.

The whole operation of a *smelting shift* takes about four hours and a half, or at most five hours, in which four periods may be distinguished.

1. The *first fire* for roasting the ores, requires very moderate firing and lasts two hours.

2. The *second fire*, or the smelting, requires a higher heat, with shut doors; at the end the slags are *dried up* with lime, and the furnace is also allowed to cool a little.

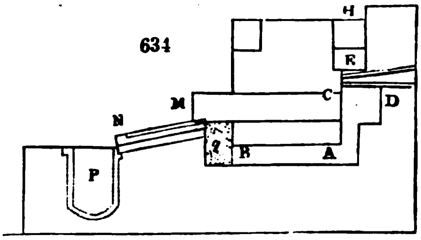
3, 4. The last two periods, or the *third and fourth fires*, are likewise two smeltings or foundings, and differ from the first only in requiring a higher temperature. The heat is greatest in the last. The form and dimensions of the furnace are calculated to cause a uniform distribution of heat over the whole surface of the hearth. Sometimes billets of green wood are plunged into the metallic lead of the outer basin, causing an ebullition which favors the separation of the slags, and consequently the production of a purer lead; but no more metallic metal is obtained.

Ten cwts. of coal are consumed at Holywell in smelting one ton of the lead-ore *schlich* or sludge; but at Grassington, near Skipton in Yorkshire, with a similar furnace worked with a slower heat, the operation taking from seven hours to seven hours and a half, instead of five, only 7½ cwts. of coal are consumed. But here the ores are less refractory, have the benefit of fluor spar as a flux, and are more exhausted of their metal, being smelted upon a less sloping hearth.

Theory of the above operation. — At Holywell, Grassington, and in Cornwall, the result of the first graduated roasting heat, is a mixture of undecomposed sulphuret of lead, with sulphate and oxyde of lead, in proportions which vary with the degree of care bestowed upon the process. After the roasting, the heat is raised to convert the sludge into a pasty mass; in which the oxyde and sulphate react upon the sulphuret, so as to produce a sub-sulphuret, which parts with the metal by liquation. The *cooling of the furnace* facilitates the liquation every time that the sub-sulphuret is formed, and the ore has passed by increase of temperature from the pasty into the liquid state. *Cooling* brings back the sludge to the pasty condition, and is therefore necessary for the due separation of the different bodies. The drying up of the thin slags by lime is intended to liberate the oxyde of lead, and allow it to react upon any sulphuret which may have resisted roasting or decomposition. It is also useful as a *thickener*, in a mechanical point of view. The iron of the tools, which wear away very fast, is also serviceable in reducing the sulphuret of lead. The small coal added along with the lime at Grassington, and also sometimes at Holywell, aids in reducing the oxyde of lead, and in transforming the sulphate into sulphuret.

3. *The smelting furnace or ore hearth.*—This furnace, called by the French *écossais*, is from 22 to 24 inches in height and 1 foot by 1½ in area inside; but its horizontal section, always rectangular, varies much in its dimensions at different lèvels, as shown in *fig.* 634.

634



The hearth and the sides are of cast iron; the sole-plate A B is also of cast iron, 2½ inches thick, having on its back and two sides an upright ledge, A C, 2½ inches thick and 4¼ high. In front of the hearth there is another cast iron plate M N, called the *work stone*, surrounded on every side excepting towards the sole of the furnace, by a ledge one inch in thickness and height. The plate slopes from behind forwards, and its posterior ledge, which is about 4½ inches above the surface of the hearth, is separated from it by a void space *q*, which is filled with a mixture of bone ash and galena, both in fine powder, moistened and pressed down together. The melted lead cannot penetrate into this body, but after filling the basin at the bottom of the furnace, flows naturally out by the gutter (nearly an inch deep) through a groove in the *work-stone;* and then passes into a caldron of reception P, styled the *melting-pot*, placed below the front edge of the *work-stone.*

The posterior ledge of the sole is surmounted by a piece of cast iron C D, called the *back-stone*, 28 inches long, and 6½ high; on which the *tuyère* or blast-pipe is placed. It supports another piece of cast iron E, called *pipe-stone*, scooped out at its under part, in the middle of its length, for the passage of the *tuyère*. This piece advances 2 inches into the interior of the furnace, the back wall of which is finally crowned by another piece of cast iron E H, called also *back-stone*.

On the ledges of the two sides of the sole, are placed two pieces of cast iron, called *bearers*, each of which is 5 inches in breadth and height, and 26 inches long. They advance an inch or two above the posterior and highest edge of the *work-stone*, and contribute effectually to fix it solidly in its place. These bearers support, through the intervention of several ranges of fire-bricks, a piece of cast iron called a *fore-stone*, which has the same dimensions as the piece called the *back-stone*, on which the base of the blowing-machine rests. This piece is in contact, at each of its extremities, with another mass of cast iron, 6 inches cube, called the *key-stone*, supported on the masonry. Lastly, the void spaces left between the two *key-stones* and the back part of the furnace are filled up with two masses of cast iron exactly like the key-stones.

The front of the furnace is open for about 12 inches from the lower part of the front cross-piece called *fore-stone*, up to the superior part of the *work-stone*. It is through this opening that the smelter operates.

The gaseous products of the combustion, on escaping from this ore-hearth, are frequently made to pass through a long flue, sloped very slightly upwards, in which they deposite all the particles of ore that they may have swept along; these flues, whose length is sometimes more than 100 yards, are usually 5 feet high and 3 feet wide in the inside, and always terminate in the chimney stalk. The matters deposited near the commencement of the flue require to be washed; but not the other dusty deposites. The whole may then be carried back to the roasting furnace, to be calcined and reagglutinated, or introduced without any preparation into the *slag-hearth*.

4. *Figs*. 635, 636 represent a slag-hearth, the *fourneau à manche* (elbow furnace) of the French, and the *krummofen* (crooked furnace) of the Germans; such as is used at Alston Moor, in Cumberland, for the reduction of the lead-slag. It resembles the Scotch furnace. The shaft is a parallelopiped, whose base is 26 inches by 22 in area inside, and whose height is 3 feet; the sole-plate *a*, of cast iron, slopes slightly down to the basin of reception, or the fore-hearth *b*. Upon both of the long sides of the sole-plate there are cast iron beams, called *bearers* c c, of great strength, which support the side walls built of a coarse grained sand-stone, as well as the cast iron plate *d* (*fore stone*), which forms

the front of the shaft. This stands 7 inches off from the sole-plate, leaving an empty space between them. The back side is made of cast iron, from the sole-plate to the horizontal tuyère in its middle; but above this point it is made of sand-stone. The tuyère is from 1½ to 2 inches in diameter. In front of the fore-hearth *b*, a cistern *e* is placed, through which water continually flows, so that the slags which spontaneously overflow the fore-hearth may become inflated and shattered, whereby the lead disseminated through them may be readily separated by washing. The lead itself flows from the fore-hearth *b*, through an orifice, into an iron pot *f*, which is kept hot over a fire. The metal obtained from this slag-hearth is much less pure than that extracted directly from the ore.

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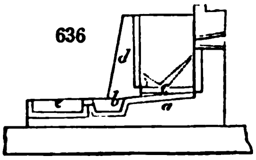

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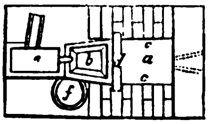
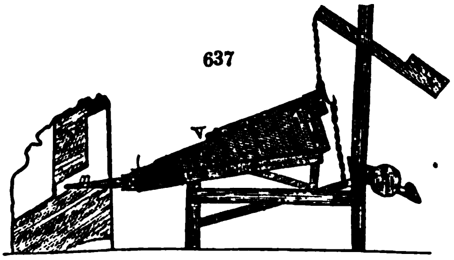


The whole bottom of the furnace is filled to a height of 17 inches, that is, to within 2 or 3 inches of the tuyère, with the rubbish of coke reduced to coarse powder and beat strongly down. At each *smelting shift*, this bed must be made anew, and the interior of the furnace above the tuyère repaired, with the exception of the front, consisting of cast iron. In advance of the furnace there is a basin of reception, which is also filled with coke rubbish. Farther off is a pit, full of water, replenished by a cold stream, which incessantly runs in through a pipe. The scoriæ, in flowing out of the furnace, pass over the coke bed in the basin of reception, and then fall into the water, whose coolness makes them fly into small pieces, after which they are easily washed, so as to separate the lead that may be entangled among them.

These furnaces are urged, in general, by wooden bellows; *fig.* 637. But at the smelting works of Lea, near Matlock, the blowing-machine consists of two casks, which move upon horizontal axes. Each of these casks is divided into two equal parts by a fixed plane that passes through its axis, and is filled with water to a certain height. The water of one side communicates with that of the other by an opening in the lower part of the division. Each cask possesses a movement of oscillation, produced by a rod attached to a crank of a bucket-wheel. At each demi-oscillation, one of the compartments, being in communication with the external air, is filled; while the other, on the contrary, communicates with the nozzle, and supplies wind to the furnace.

637



5. *Refining or cupellation furnace.* See SILVER.

6. *Smelting by the reverberatory furnace* is adopted exclusively in Derbyshire, and in some works at Alston Moor. The charge in the hopper consists commonly of 16 cwts., each weighing 120 lbs. avoirdupois, composed of an intimate mixture of 5, 6, 7, or even 8 kinds of ore, derived from different mines, and prepared in different ways. The proportions of the mixture are determined by experience, and are of great consequence to the success of the work.

The ore is rather in the form of grains than of a fine *schlich*; it is sometimes very pure, and affords 75 *per cent.*; but usually it is mixed up with a large proportion of carbonate and fluate of lime; and its product varies from 65 to 23 *per cent.*

After scraping the slaggy matters out of the furnace, a fresh smelting shift is introduced at an interval of a few minutes; and thus, by means of two alternate workmen, who relieve each other every seven or eight hours, the weekly operations continue without interruption. The average product in lead of the reverberatory furnaces in Derbyshire, during several years, has been 66 per cent. of the ore. Very fine ore has, however, afforded 76.

7. *Smelting of the drawn slag, on the slag-mill hearth.*—The black slag of the reverbe-

ratory furnace is broken by hammers into small pieces, and mixed in proper proportions with the coal cinders that fall through the grate of the reverberatory fire. The leaden *matts* that float on the surface of the bath, and the dust deposited in the chimney, are added, along with some poor ore containing a gangue of fluor spar and limestone, which had been put aside during the machanical preparation. With such a mixture, the slag-hearth, already described *figs.* 635, 636, is charged. By the action of heat and coal, the lead is revived, the earthy matters flow into very liquid scoriæ, and the whole is made to pass across the body of fire into a basin of reception placed beneath. The scoriæ are thickened by throwing quicklime upon them, and they are then raked away. At the end of the operation the lead is cast into pigs or ingots of a peculiar form. This is called slag-lead. It is harder, more sonorous than the lead obtained from the reverberatory furnace, and is preferred for the manufacture of minium, lead shot, and some other purposes.

8. *Treatment of lead ores by the Scotch furnace, or ore-hearth.*—This furnace is generally employed in the counties of Northumberland, Cumberland, and Durham, for the smelting of lead ores, which were formerly carried to them without any preparation, but now they are exposed to a preliminary calcination. The roasted ore yields in the Scotch furnace a more considerable product than the crude ore, because it forms in the furnace a more porous mass, and at the same time *it works drier*, to use the founder's expression; that is, it allows the stream of air impelled by the bellows to diffuse itself more completely across the matters contained in the furnace.

The charge of the *roasting* furnace, *figs.* 631, 632, 633, is from 9 to 11 cwts. of ore, put into the furnace without any addition. Three such shifts are usually passed through in eight hours. The fire should be urged in such a manner as to produce constantly a dense smoke, without letting any part of the ore melt and form a slag; an accident which would obstruct the principal end of the process, which is to burn off the sulphur and antimony, and to expel the carbonic acid of the carbonate of lead. The ore must be frequently turned over, by moving it from the bridge to the other end and back again. To prevent the ore from running into masses as it cools, it is made to fall out of the furnace into a pit full of water, placed below one of the lateral doors.

Smelting of the lead ores in the Scotch furnace.—When a *smelting shift* has been finished in the Scotch furnace, a portion of the ore, called *browse*, remains in a semi-reduced state, mixed with coke and cinders. It is found of more advantage to preserve the browse for beginning the following operation, than to take raw or even roasted ore. To set the furnace in action, the interior of it is filled with peats, cut into the form of bricks. The peats towards the posterior part are heaped up without order, but those near the front are piled up with care in the form of a wall. A kindled peat is now placed before the nozzle of the bellows, which are made to blow, and the blast spreads the combustion rapidly through the whole mass. To increase the heat, and to render the fire more steady and durable, a few shovelfuls of coals are thrown over the turf. A certain quantity of the browse is to be next introduced; and then (or sometimes before all the browse is put in) the greater part of the matters contained in the furnace is drawn over on the *work-stone*, by means of a large rake called a *gowelock;* the refuse of the ore called *gray slag*, which a skilful smelter knows by its shining more than the browse, is taken off with a shovel, and thrown to the right hand into a corner outside of the furnace. The browse left on the work-stone is to be now thrown back into the furnace, with the addition of a little coal, if necessary. If the browse be not well cleaned from the slag, which is perceived by the whole mass being in a soft state, and showing a tendency to fuse, quicklime must be added, which by its affinity for the argillaceous, silicious, and ferruginous substances, dries up the materials, as the smelters say, and gives to the earthy parts the property of concreting into lumps or balls; but if, on the other hand, the silicious, argillaceous, or ferruginous parts contained in the ore be too refractory, lime is also to be added, but in smaller quantity, which, by rendering them more fusible, communicates the property of concreting into balls. These lumps, called gray slag, contain from one tenth to one fifteenth of the lead which was present in the ore. They must be smelted afterwards at a higher temperature in the slag hearth, to extract their lead. After the browse has been thrown back into the furnace, as has been said, a few shovelfuls of ore are to be strewed over it; but before doing this, and after removing the scoriæ, there must be always placed before the tuyère half a peat, a substance which being extremely porous and combustible, not only hinders any thing from entering the nozzle of the bellows, but spreads the blast through all the vacant parts of the furnace. After an interval of from 10 to 15 minutes, according to circumstances, the materials in the furnace are drawn afresh upon the work-stone, and the gray slag is removed by the rake. Another peat being placed before the tuyère, and coal and quicklime being introduced in suitable proportions, the browse is thrown back into the furnace, a fresh portion of ore is charged above it, and left in the furnace for the above-mentioned time.

This mode of working, continued for 14 or 15 hours, forms what is called a *smelting shift*; in which time from 20 to 40 cwts. of lead, and even more, are produced.

By this process the purest part of the lead, as well as the silver, are sweated out, as it were, from the materials with which they are mixed, without anything entering into fusion except these two metals in the state of alloy. It is probable that the moderate temperature employed in the Scotch furnace is the main cause of the purity of the lead which it yields.

9. *Smelting of the scoriæ of the Scotch furnace on the slag hearth.*—Before putting fire to the slag hearth already described, *figs.* 635, 636, its empty space is to be filled with peats, and a lighted one being placed before the tuyère, the bellows are made to play. A layer of coke is to be now thrown upon the burning peats, and as soon as the heat is sufficiently high, a layer of the *gray slag* is to be introduced, or of any other scoriæ that are to be reduced. From time to time, as the fit moment arrives, alternate strata of coke and slag are to be added. In this operation, though the slag and the lead are brought to a state of perfect fluidity, the metal gets separated by filtering down through the bed of peat cinders, which the slag cannot do on account of its viscidity. Whenever that coke bed becomes covered with fluid slag, the workman makes a hole in it, of about an inch diameter, by means of a kneed poker; and runs it off by this orifice, as it cannot sink down into the hard rammed cinders, which fill the basin of reception. The slag flows over it in a glowing stream into the pit filled with water, where it gets granulated and ready for washing.

When lead is obtained from galena without the addition of combustible matter, we have an example, on the great scale, of the mutual decomposition of the oxydes and sulphates formed during the roasting heat, by the still undecomposed galena, especially when this action is facilitated by working up and skilfully mingling the various matters, as happens in the reverberatory and Scotch furnaces. It is therefore the sulphuret of lead itself which serves as the agent of reduction in regard to the oxyde and sulphate, when little or no charcoal has been added. Sometimes, however, towards the end of the operation in the reverberatory hearth, it becomes necessary to throw in some wood or charcoal, because the oxydizement having become too complete, there does not remain a sufficient body of sulphuret of lead to effect the decompositions and reductions just mentioned, and therefore it is requisite to regenerate some galena by means of carbonaceous matter, which immediately converts the sulphate of lead into the sulphuret. The sulphur and oxygen are eventually all separated in the form of sulphurous acid. Roasted galena contains sometimes no less than 77 per cent. of sulphate of lead.

At Viconago, in the Valais, the process of smelting lead ore in the reverberatory furnace, with the addition of iron, as practised at Vienne, on the Isère, was introduced; but the difficulty of procuring a sufficient supply of old iron has led to an interesting modification.

On the hearth of the reverberatory furnace, 10 quintals of moderately rich ore are spread; these are heated temperately for some time, and stirred about to promote the sublimation of the sulphur. After three or four hours, when the ore seems to be sufficiently desulphureted, the heat is raised so as to melt the whole materials, and whenever they flux into a metallic glass, a few shovelfuls of bruised charcoal or cinders are thrown in, which soon thicken the liquid, and cause metallic lead to appear. By this means three fourths of the lead contained in the ore are usually extracted; but at length the substance, becoming less and less fluid, yields no more metal. Stamped and washed carbonate of iron (sparry iron ore) is now added, in the proportion of about 10 per cent. of the lead ore primarily introduced.

On stirring and working together this mixture, it assumes the consistence of a stiff paste, which is raked out of the furnace. When this has become cold, it is broken into pieces, and thereafter smelted in a slag-hearth, without the addition of flux. By this operation almost the whole lead present is obtained. 100 quintals of schlich yield 45 of argentiferous lead; and in the production of 100 quintals (cwts.) of marketable lead, 140 cubic feet of beech-wood, and 357½ quintals of charcoal are consumed.

This process is remarkable for the use of iron-ore in smelting galena.

10. *Reduction in the reverberatory furnace of the litharge obtained in the refining of lead.*—The litharge of Alston Moor is seldom sold as such, but is usually converted into lead, in a reverberatory furnace.

In commencing this reduction, a bed of coal about 2 inches thick is first of all laid on the hearth; which is soon kindled by the flame of the fire-place, and in a little while is reduced to red hot cinders. Upon these a certain quantity of a mixture of litharge and small coal is uniformly spread; the heat of the fire-place being meanwhile so managed as to maintain in the furnace a suitable temperature for enabling the combustible to deprive the litharge of its oxygen, and to convert it into lead. The metal is run out by the tap-hole into an iron pot; and being cast into pigs of half a hundred weight, is sold under the name of refined lead at a superior price.

The quantity of small coal mixed with the litharge should be somewhat less than what may be necessary to effect the reduction, because if in the course of the process a deficiency of it is perceived in any part of the furnace, more can always be added; whereas a redundancy of coal necessarily increases the quantity of slag, which, at the end of the shift, must be removed from the furnace before a new operation is begun, whereby lead is lost. In the reverberatory furnace, six fodders of lead may be revived in nine or ten hours; during the first six of which the mixture of litharge and coal is added at short intervals. A fodder is from 21 to 24 cwts.

It deserves to be remarked that the work does not go on so well nor so quick when the coal and litharge are in a pulverulent form; because the reduction in this case takes place only at the surface, the air not being able to penetrate into the body, and to keep up its combustion, and the mutual action of the litharge and carbon in the interior. But, on the other hand, when the litharge is in porous pieces, as large as a hen's egg, the action pervades the whole body, and the sooty fumes of the coal effect the reduction even in the centre of the fragments of the litharge, penetrating into every fissure and carrying off the oxygen. The heat ought never to be urged so far as to melt the litharge.

The grounds of the cupel, and the slag of the reduction furnace, being a mixture of small coke, coal ash, and oxyde of iron, more or less impregnated with lead, are smelted upon the *slag hearth*, along with coke, and, by way of flux, with a certain quantity of the black scoriæ obtained from the same furnace, prepared for this purpose, by running it out in thin plates, and breaking it into small pieces. The lead thus obtained is usually very white, very hard, and not susceptible of refinement.

MM. Dufrénoy and Beaumont consider the smelting of lead ore by the reverberatory furnace, as practised in Derbyshire, as probably preferable to that with the slag hearth as carried on in Brittany; a process which seldom gives uniform products, while it occasions a more considerable waste of lead and consumption of fuel.

The mixed process employed in Cumberland of roasting the ore, and afterwards smelting it in a small furnace resembling that called the Scotch, apparently yields a little less lead than if both operations were executed in the reverberatory furnace; but according to Mr. Forster (see his *Treatise on a Section of the Strata from Newcastle upon Tyne*, &c.), this slight loss is more than compensated by the smaller consumption of fuel, the increased rapidity of the operation, and especially by the much greater purity of the lead obtained from the Scotch furnace. When it comes to be refined, the loss is only about one twelfth or one thirteenth, whereas the lead revived in the reverberatory furnace loses frequently a ninth. Moreover, the lead furnished by the first method admits of being refined with profit, when it yields only 5 ounces of silver per fodder of 20 quintals, *poids de marc*, while that produced by the reverberatory furnace cannot be cupelled unless it gives 10 ounces per fodder; and as in the English cupellation lead is constantly added anew without skimming, the litharge obtained in the second case can never be brought into the market, whereas the litharge of the leads from the Scotch furnace is of good quality. See the new method of enriching lead for cupellation, under SILVER.

As the *smelting* of galena, the principal ore of lead, is not a little complex, the following tabular view of the different processes may prove acceptable to the metallurgist:—

		Treatment of	Process of
I. Class. Treated in reverberatory furnaces.	A Desulphuration by roasting.	1. Pure ores.	Pesey, Spain, &c.
		2. Ores mixed with saline gangues.	England, in general.
		3. Ores mixed with earthy gangues.	Vicenago, in Italy, and Redruth, in Cornwall.
		4. Ores mixed with several sulphurets.	Combined with the above.
		5. Ores with earthy, saline, and sulphurous gangues.	
	B Desulphuration by iron.	6. Ores with mattes, as at Vienne, in Dauphiny.	Vienne, Poullaouen, and Tarnowitz.

		Treatment of	Process of	
II. Class. Treated in the mill-slag-hearth, the *fourneau à manche*, or Scotch furnace.	A Founding after roasting in a heap, or in a reverberatory.	7. Ores producing slags of various silicates.	Mattes, with raw lead.	Many places.
			Workable lead, without mattes.	Villefort.
		8. Ores producing compound silicate slags.	Mattes and workable lead.	Several places.
			Workable lead.	PontGibaud and Scotch furnace.
	B Founding with direct desulphuration, by metallic iron.	9. Ores producing slags composed of silicates and subsilicates.	Mattes and workable lead.	Baad-Ems Hartz, Tarnowitz.
			Poor mattes and workable lead.	Tarnowitz.

The annual production of lead in Europe may be estimated at about 80,000 tons; of which four sevenths are produced in England, two sevenths in Spain, the remainder in Germany and Russia. France does not produce more than one five-hundredth part of the whole; and only one fiftieth of its consumption.

See Litharge, Minium, or *Red Lead*, Solder, Sugar or *Acetate* of Lead, Type Metal, and White Lead.

LEAD-SHOT (*Plomb de chasse*, Fr.; *Schrot*, *Flintenschrot*, Germ.). The origin of most of the imperfections in the manufacture of lead-shot is the too rapid cooling of the spherules by their being dropped too hot into the water, whereby their surfaces form a solid crust, while their interior remains fluid, and, in its subsequent concretion, shrinks, so as to produce the irregularities of the shot.

The patent shot towers originally constructed in England obviate this evil by exposing the fused spherules after they pass through the cullender, to a large body of air during their descent into the water tub placed on the ground. The greatest erection of this kind is probably at Villach, in Carinthia, being 240 Vienna, or 249 English feet high.

The quantity of arsenic added to the mass of melted lead, varies according to the quality of this metal; the harder and less ductile the lead is, the more arsenic must be added. About 3 pounds of either white arsenic or orpiment is enough for one thousand parts of soft lead, and about 8 for the coarser kinds. The latter are employed preferably for shot, as they are cheaper and answer sufficiently well. The arsenical alloy is made either by introducing some of this substance at each melting, or by making a quantity of the compound considerably stronger at once, and adding a certain portion of this to each charge of lead. If the particles of the shot appear lens shaped, it is a proof that the proportion of arsenic has been too great; but if they are flattened upon one side, if they are hollowed in their middle, called *cupping* by the workman, or drag with a tail behind them, the proportion of arsenic is too small.

The following is the process prescribed by the patentees, Ackerman and Martin. Melt a ton of soft lead, and sprinkle round its sides, in the iron pot, about two shovelfuls of wood ashes, taking care to leave the centre clear; then put into the middle about 40 pounds of arsenic to form a rich alloy with the lead. Cover the pot with an iron lid, and lute the joints quickly with loam or mortar, to confine the arsenical vapors, keeping up a moderate fire to maintain the mixture fluid for three or four hours; after which skim carefully, and run the alloy into moulds to form ingots or pigs. The composition thus made is to be put in the proportion of one pig or ingot into 1000 pounds of melted ordinary lead. When the whole is well combined, take a perforated skimmer and let a few drops of it fall from some height into a tub of water. If they do not appear globular, some more arsenical alloy must be added.

Lead which contains a good deal of pewter or tin must be rejected, because it tends to produce elongated drops or tails.

From two to three tons are usually melted at once in the large establishments. The surface of the lead gets covered with a crust of oxyde of a white spongy nature, sometimes called *cream* by the workmen, which is of use to coat over the bottom of the cullender, because without such a bed the heavy melted lead would run too rapidly through the holes for the granulating process, and would form oblong spheroids. The mounting of this filter, or lining of the cullender, is reckoned to be a nice operation by the workmen, and is regarded usually as a valuable secret.

The cullenders are hollow hemispheres of sheet iron, about 10 inches in diameter, perforated with holes, which should be perfectly round and free from burs. These must be of a uniform size in each cullender; but of course a series of different cullenders, with sorted holes for every different size of lead shot, must be prepared. The holes have nearly the following diameters for the annexed numbers of shot.

No. 0.	$\frac{1}{50}$ of an inch
1.	$\frac{1}{58}$ —
2.	$\frac{1}{66}$ —
3.	$\frac{1}{72}$ —
4.	$\frac{1}{80}$ —

From No. 5 to No. 9 the diameter decreases by regular gradations, the latter being only $\frac{1}{360}$ of an inch.

The operation is always carried on with three cullenders at a time; which are supported upon projecting grates of a kind of chafing dish made of sheet iron somewhat like a triangle. This chafing dish should be placed immediately above the fall; while at its bottom there must be a tub half filled with water for receiving the granulated lead. The cullenders are not in contact, but must be parted by burning charcoal, in order to keep the lead constantly at the proper temperature, and to prevent its solidifying in the filter. The temperature of the lead bath should vary with the size of the shot; for the largest, it should be such that a bit of straw plunged into it will be scarcely browned, but for all it should be nicely regulated. The height from which the particles should be let fall varies likewise with the size of the shot; as the congelation is the more rapid, the smaller they are. With a fall of 33 yards or 100 feet, from No. 4 to No. 9 may be made; but for larger sizes, 150 feet of height will be required.

Every thing being arranged as above described, the workman puts the filter-stuff into the cullender, pressing it well against the sides. He next pours lead into it with an iron ladle, but not in too great quantity at a time, lest it should run through too fast. The shot thereby formed and found in the tub are not all equal.

The centre of the cullender being less hot affords larger shot than the sides, which are constantly surrounded with burning charcoal. Occasionally, also, the three cullenders employed together may have holes of different sizes, in which case the tub may contain shot of very various magnitudes. These are separated from each other by square sieves of different fineness, 10 inches broad and 16 inches long; their bottoms being of sheet iron, pierced with holes of the same diameters as those of the cullenders. These sieves are suspended by means of two bands above boxes for receiving the shot; one sieve being usually set above another in consecutive numbers, for instance, 1 and 2. The shot being put into the upper sieve, No. 0 will remain in it, No. 1 will remain in the lower sieve, and No. 2 will, with all the others, pass through it into the chest below. It is obvious that by substituting sieves of successive fineness, shot of any dimension may be sorted.

In the preceding process the shot has been sorted to size; it must next be sorted to form, so as to separate all the spheroids which are not truly round, or are defective in any respect. For this purpose a board is made use of about 27 inches long and 16 broad, furnished partially with upright ledges; upon this tray a handful or two of the shot to be sorted being laid, it is inclined very slightly, and gently shaken in the horizontal direction, when the globular particles run down by one edge, into a chest set to receive them, while those of irregular forms remain on the sides of the tray, and are reserved to be remelted.

After being sorted in this way, the shot requires still to be smoothed and polished bright. This object is effected by putting it into a small octagonal cask, through a door in its side, turning upon a horizontal iron axis, which rests in plummer boxes at its ends, and is made to revolve by any mechanical power. A certain quantity of plumbago or black lead is put in along with the shot.

LAZULITE (Eng. and Fr.; *Lazulith*, Germ.) is a blue vitreous mineral, crystallizing in rhomboidal dodecahedrons; spec. grav., 2·76 to 2·94; scratches glass; affords a little water by calcination; fusible into a white glass; dissolves in acids with loss of color; solution leaves an alkaline residuum, after being treated with carbonate of ammonia, filtered, evaporated, and calcined. It consists of silica, 35·8; alumina, 34·8; soda, 23·2; sulphur, 3·1; carbonate of lime, 3·1. This beautiful stone affords the native *ultramarine* pigment, which was very costly till a mode of making it artificially was lately discovered. See ULTRAMARINE.

LEATHER (*Cuir*, Fr.; Germ., *Leder*) is the skin of animals, so modified by chemical means as to have become unalterable by the external agents which tend to decompose it in its natural state. The preparation in a rude manner of this valuable substance, has been known from the most ancient times, but it was not till the end of the last, and the beginning of the present century, that it began to be manufactured upon right principles, in consequence of the researches of Macbride, Deyeux, Seguin, and Davy. There are several varieties of leather, such as sole leather, boot or upper leather, shamoy leather, kid or glove leather, &c. Skins may be converted into leather either with or without their hairy coat.

We shall treat first of sole and upper leathers, being the most important, and most costly and difficult to prepare in a proper manner. These kinds consist of organized fibrous gelatine or skin, combined with the proximate vegetable principle, tannin, and probably also some vegetable extractive. Under the articles GALLS and TANNIN, will be found an account of the properties of this substance, and the means of obtaining it in a state of purity. Calf leather quickly tanned by an infusion of galls, consists of 61 parts of skin, and 39 of vegetable matter in 100 by weight; by solution of catechu, it consists of 80 of skin, and 20 of vegetable matter; by infusion of Leicester willow, of 74·5 skin, and 25·5 vegetable matter; and by infusion of oak bark, of 73·2 skin, and 26·8 vegetable matter. By the slow process of tanning, continued for three months, the increase of weight upon the skin in its conversion into leather, is greatly less; the vegetable constituents being from Leicester willow only 13 per cent. of the leather, and from oak bark 15 per cent. Sole leather, however, generally contains no less than 40 per cent. of vegetable matter. In every astringent bark, the inner white part next to the *alburnum*, contains the largest quantity of tannin, and the middle colored part contains most extractive matter. The outer surface or epidermis seldom furnishes either tannin or extractive matter. Young trees abound most in the white cortical layers, and are hence more productive of tannin under equal weights, than the barks of old trees. In no case is there any reason to believe that the gallic acid of astringent vegetables is absorbed in the process of making leather; hence Seguin's theory of the agency of that substance in disoxygenating skin, falls to the ground. The different qualities of leather made with the same kind of skin, seem to depend very much upon the different quantities of extractive matter it may have absorbed. The leather made with infusion of galls, is generally harder and more liable to crack than the leather obtained from infusions of barks; and it always contains a much larger proportion of tannin, and a smaller proportion of extractive matter.

When calf skin is slowly tanned in weak solutions of the bark, or of catechu, it combines with a good deal of extractive matter, and though the increase of the weight of the skin be comparatively small, yet it has become perfectly insoluble in water, forming a soft, but at the same time a strong leather. The saturated infusions of astringent barks contain much less extractive matter in proportion to their tannin, than the weak infusions; and when skin is quickly tanned in the former, it produces a worse and less durable leather than when slowly tanned in the latter. In quick tanning, a considerable quantity of vegetable extractive matter is thus lost to the manufacturer, which might have been made to enter as a useful constituent into the leather. These observations show that there is sufficient foundation for the opinion of the common workmen, concerning what is technically called *feeding* of leather, in the slow method of tanning; and though the processes of this art have been unnecessarily protracted by defective methods of steeping, and want of progressive infiltration of the astringent liquor through the skins, yet in general they appear to have arrived, in consequence of old experience, at a degree of perfection in the quality of the leather, which cannot be far exceeded by means of any theoretical suggestions which have been advanced.

On the first view it may appear surprising, that in those cases of quick tanning, where extractive matter forms a certain portion of the leather, the increase of weight is less than when the skin is combined with the pure tannin; but the fact is easily accounted for, when we consider that the attraction of skin for tannin must be probably weakened by its union with extractive matter; and whether we suppose that the tannin and extractive matter enter together into combination with the matter of skin, or unite with separate portions of it, still, in either case, the primary attraction of skin for tan must be to a certain extent diminished.

In examining astringent vegetables in relation to their power of making leather, it is necessary to take into account not only the quantity they may contain of the *substance* precipitable by gelatine, but likewise the quantity and the nature of the extractive matter; and in cases of comparison, it is essential to employ infusions of the same degree of concentration.

Of all astringent substances hitherto examined, catechu is that which contains the largest proportion of tannin; and in supposing, according to the usual estimation, that from four to five pounds of common oak bark are required to produce one pound of leather, it appears, from the various synthetical experiments, that about half a pound of catechu would answer the same purpose. Mr. Purkis found, by the results of different accurate experiments, that 1 pound of catechu was equivalent to 7 or 8 of oak bark. For the common purposes of the tanner, 1 pound of it would be equivalent also to 2½ pounds of galls, to 7½ of the Leicester willow, to 11 of the bark of the Spanish chestnut, to 18 of the bark of the common elm, to 21 of the bark of the common willow, and to 3 pounds of sumach.

Various menstrua have been proposed for the purpose of expediting and improving the process of tanning, among others, lime water, and solution of pearl-ash; but as these two substances form compounds with tannin which are not decomposable by gelatine, it follows that their effects must be prejudicial. There is very little reason to suppose that any bodies will be found which, at the same time that they increase the solubility of tannin in water, will not likewise diminish its attraction for skin.

In this country all tanned leather is distinguished into two kinds, called *hides* and *skins*; the former term being appropriated to that made from the larger animals, as bulls, buffaloes, oxen, and cows, into thick strong sole leather; and the latter to that made from calves, seals, &c., into thinner and more flexible upper leather. Sometimes the hides are brought into the market merely dried, as from Buenos Ayres; or dried and salted, as from Bahia and Pernambuco; but the greater part are fresh from recently slaughtered animals. The heaviest ox-hides are preferred for forming *butts* or *backs*, which are manufactured as follows :—

The washing process must be more or less elaborate, according to the state of the skins. Those that are salted and dry require to be steeped, beaten, and rubbed several times alternately, to bring them to the fresh condition.

After removing the horns, the softened or recent hides are laid in a heap for two or three days, after which they are suspended on poles in a close room called a smoke-house, heated somewhat above the common temperature by a smouldering fire. In these circumstances, a slight putrefaction supervenes, which loosens the epidermis, and renders the hair easily detachable by the *fleshing knife*; a large two handled implement, with a blunt edge, and bent to suit the curvature of the rounded beam of the wooden horse upon which the hide is scraped. See CURRYING.

The next step is immersion in a pit containing water impregnated with about a 1000th part of sulphuric acid. This process is called *raising*, because it distends the pores, and makes the fibres swell, so as to render the skins more susceptible of the action of the tanning infusions. Forty-eight hours in general suffice for this operation, but more time may be safely taken.

When the hides are found to be sufficiently raised, they are transferred to a pit, in which they are stratified with oak bark, ground by a proper mill into a coarse powder. The pit is then filled up with an infusion of oak bark called ooze, and the hides are allowed to remain in it for about a month or six weeks. By this time the tannin and extractive matter of the bark having combined intimately with the animal fibre, the pit is exhausted of its virtue, and must be renewed, by taking out the spent bark, and subjecting the skins to a fresh dose of oak bark and ooze. The hides which were placed near the top of the first pit, must be placed near the bottom of the next. In this mixture they remain, upon the old practice, about three months. The last process being repeated twice or thrice, perfectly tanned leather is the result. The hides are now removed from the pit, and hung up in a shed. In the progress of drying, which should be slow, they are compressed with a steel tool, and beaten smooth, to render them more firm and dense.

Some manufacturers place on the bottom of the pit 5 or 6 inches of spent bark, over it 2 inches of fresh bark, then a skin; and so, alternately, a layer of new bark and a skin, till the pit is nearly full, reserving a small space at top for a thicker layer of bark, over which weighted boards are laid, to condense the whole down into the tanning infusion.

The operation of tanning sole leather in the above way, lasts a year or a year and a half, according to the quality wanted, and the nature of the hides.

A perfect leather is recognised by its section, which should have a glistening marbled appearance, without any white streaks in the middle.

Crop hides are manufactured by immersion, during three or four days, in pits containing milk of lime; in which they are occasionally moved up and down in order to expose them equally to the action of this menstruum. They are then removed, and cleared from hair and impurities, by using the fleshing knife upon the horse; after which they must be completely freed from the lime by a thorough washing. They are next plunged in pits containing a weak ooze or infusion of oak bark, from which they are successively transferred into other pits with stronger ooze; all the while being daily *handled*, that is, moved up and down in the infusion. This practice is continued for about a month or six weeks. They are now ready to be subjected to a mixture of ground oak bark and stronger ooze in other pits, to a series of which they are progressively subjected during two or three months.

The hides are next put into large vats, called *layers*, in which they are smoothly stratified with more oak bark, and a stronger infusion of it. After six weeks they are taken out of these vats, and subjected to a new charge of the same materials for two months. This simple process is repeated twice or thrice, at the option of the manufacturer, till the hides are thoroughly tanned. They are then slowly dried, and condensed in the manner above described. These crop hides form the principal part of the sole leather used for home consumption in England.

The process of tanning *skins* (as of calves, seals, &c.) is in some respects peculiar. They are left in the lime pits for about twelve days, when they are stripped of their hair, washed in water, then immersed in a lixivium of pigeons' dung, called a *grainer*, of an alkaline nature. Here they remain from eight to ten days, according to the state of the atmosphere, during which time they are frequently handled, and scraped on both sides upon a convex wooden beam. This scraping or *working*, as it is termed, joined to the action of the *grainer*, serves to separate the lime, oil, and glutinous matter, and to render the skin pliant, soft, and ready to imbibe the tanning principle. They are with this view transferred into pits containing a weak solution of bark, in which they undergo nearly the same treatment as described above for *crop* hides; but they are not commonly stratified in the layers. The time occupied in tanning them is usually limited to three months. They are then dried, and disposed of to the currier, who dresses and blackens them for the upper leathers of boots and shoes, for harness, and other purposes. The light and thin sorts of cow and horse hides are often treated like calf skins.

In all the above processes, as the animal fibres on the surface of the skin absorb most readily the tanning principles, and thereby obstruct, in a certain degree, their passage into the interior fibres, especially of thick hides, it becomes an object of importance to contrive some method of overcoming that obstacle, and promoting the penetration of the tan. The first manufacturer who appears to have employed efficacious mechanical means of favoring the chemical action was Francis G. Spilsbury, who in April, 1823, obtained a patent for the following operation:—After the hides are freed from the hairs, &c. in the usual way, they are minutely inspected as to their soundness, and if any holes be found, they are carefully sewed up, so as to be water tight. Three frames of wood are provided of equal dimensions, fitted to each other, with the edges of the frames held together by screw bolts. A skin about to be tanned is now laid upon the frame, and stretched over its edges, then the second frame is to be placed upon it, so that the edges of the two frames may pinch the skin all round and hold it securely; another such skin is then stretched over the upper surface of the second frame, in like manner, and a third frame being set upon this, confines the second skin. The three frames are then pinched tightly together by a series of screw bolts, passing through ears set round their outer edges, which fix the skin in a proper manner for being operated upon by the tanning liquor.

A space has been thus formed between the two skins, into which, when the frames are set upright, the infusion is introduced by means of a pipe from the cistern above, while the air is permitted to escape by a stopcock below. This cock must of course be shut whenever the bag is filled, but the one above is left open to maintain a communication with the liquor cistern, and to allow the hydrostatic pressure to force the liquor through the cutaneous pores by a slow infiltration, and thus to bring the tannin into contact with all the fibres indiscriminately. The action of this pressure is evinced by a constant perspiration on the outer surfaces of the skins.

When the tanning is completed, the upper stopcock is closed, and the under is opened to run off the liquor. The frames are now removed, the bolts are unscrewed, and the pinched edges of the skins pared off; after which they are to be dried and finished in the usual manner.

A modification of this ingenious and effectual process was made the subject of a patent, by William Drake, of Bedminster, tanner, in October, 1831. The hides, after the usual preparatory processes, are immersed in a weak tan liquor, and by frequent handling or turning over, receive an incipient tanning before being submitted to the infiltration plan. Two hides, as nearly of the same size and shape as possible, are placed grain to grain, when their corresponding edges are sewed firmly together all round by shoemakers' waxed thread, so as to form a bag sufficiently tight to hold tan liquor. This bag must then be suspended by means of loops sewed to its shoulder end, upon pegs, in such a manner that it may hang within a wooden-barred rack, and be confined laterally into a book form. About an inch of the bag is left unsewed at the upper end, for the purpose of introducing a funnel through which the cold tan liquor is poured into the bag till it be full. After a certain interval which varies with the quality of the hides, the outer surface becomes moist, and drops begin to form at the bottom of the bag. These are received in a proper vessel, and when they accumulate sufficiently may be poured back into the funnel; the bag being thus, as well as by a fresh supply from above, kept constantly distended.

When the hides are observed to feel hard and firm, while every part of them feels equally damp, the air of the tanning apartment having been always well ventilated, is now to be heated by proper means to a temperature gradually increasing from 70° to 150° of Fahrenheit's scale. This heat is to be maintained till the hides become firmer and harder in all parts. When they begin to assume a black appearance in some parts, and when the tan liquor undergoes little diminution, the hides may be considered to be tanned, and the bag may be emptied by cutting a few stitches at its bottom. The outer edges being pared off, the hides are to be finished in the usual way. During their suspension within the racks, the hides should be shifted a little sideways, to prevent the formation of furrows by the bars, and to facilitate the equable action of the liquor.

By this process the patentee says, that a hide may be tanned as completely in ten days as it could be in ten months by the usual method. I have seen a piece of sole leather thus rapidly tanned, and it seemed to be perfect. How it may wear, compared with that made in the old way, I cannot pretend to determine.

Messrs. Knowlys and Duesbury obtained a patent in August, 1826, for accelerating the impregnation of skins with tannin, by suspending them in a close vessel, from which the air is to be extracted by an air pump, and then the tanning infusion is to be admitted. In this way, it is supposed to penetrate the hide so effectually as to tan it uniformly in a short time.

About 32 years ago, a similar vacuum scheme was employed to impregnate with weavers' paste or starch, the cops of cotton weft, for the dandy looms of Messrs. Radcliff and Ross, of Stockport.

Danish leather is made by tanning lamb and kid skins with willow bark, whence it derives an agreeable smell. It is chiefly worked up into gloves.

Of the tawing or dressing of skins for gloves, and white sheep leather.

The operations of this art are: 1. washing the skins; 2. properly treating them with lime; 3. taking off the fleece; 4. treatment in the leather steep.

A shed erected upon the side of a stream, with a cistern of water for washing the skins; wooden horses for cleaning them with the back of the fleshing knife; pincers for removing the fibres of damaged wool; a plunger for depressing the skins in the pits; a lime pit; a pole with a bag tied to the end of it; a two-handed fleshing knife; a rolling pin, from 15 to 18 inches long, thickened in the middle; such are some of the utensils of a tawing establishment. There must be provided also a table for applying the oil to the skins; a fulling mill, worked by a water-wheel or other power; a dressing peg; a press for squeezing out the fatty filth; a stove; planks mounted upon legs, for stretching the skins, &c.

Fresh skins must be worked immediately after being washed, and then dried, otherwise they ferment, and contract either indelible spots, or get tender in certain points, so as to open up and tear under the tools. When received in the dry state they should be steeped in water for two days, and then treated as fresh skins. They are next strongly rubbed on the convex horse-beam with a round-edged knife, in order to make them pliant. The rough parts are removed by the fleshing knife. One workman can in this way prepare 200 skins in a day.

The flesh side of each being rubbed with a cold cream of lime, the skins are piled together with the woolly side of each pair outermost, and the flesh sides in contact. They are left in this state for a few days, till it is found that the wool may be easily removed by *plucking*.

They are next washed in running water, to separate the greater part of the lime, stripped of the wool by small spring tweezers, and then fleeced smooth by means of the rolling-pin, or sometimes by rubbing with a whetstone. Unless they be fleeced soon after the treatment with lime, they do not well admit of this operation subsequently, as they are apt to get hard.

They are now steeped in the milk of lime-pit, in order to swell, soften, and cleanse them; afterwards in a weak pit of old lime-water, from which they are taken out and drained. This steeping and draining upon inclined tables, are repeated frequently during the space of 3 weeks. Only the skins of young animals, or those of inferior value, are tawed. Sometimes the wool is left on, as for housings, &c.

The skins, after having been well softened in the steeps, are rubbed on the outside with a whetstone set in a wooden case with two handles, in order to smooth them completely by removing any remaining filaments of wool. Lamb skins are rubbed with the pin in the direction of their breadth, to give them suppleness; but sheep skins are fulled with water alone. They are now ready for the *branning*, which is done by mixing 40 lbs. of bran with 20 gallons of water, and keeping them in this fermentable mixture for three weeks—with the addition, if possible, of some old bran water. Here they must be frequently turned over, and carefully watched, as it is a delicate operation. In the course of two days in summer, and eight in winter, the skins are said to be *raised*, when they sink in the water. On coming out of the bran, they are ready for the white stuff; which is a bath composed of alum and sea-salt. Twelve, fourteen, and sometimes eighteen pounds of alum for 100 skins, form the basis of the bath; to which two and a half pounds of salt are added in winter, and three in summer. These ingredients are introduced into a copper with twelve gallons of water. The salt aids in the whitening action. When the solution is about to boil, three gallons of it are passed through the cullender into a basin; in this 26 skins are worked one after another, and, after draining, they are put together into the bath, and left in it for ten minutes to imbibe the salts. They are now ready to receive the paste. For 100 skins, from 13 to 15 pounds of wheat flour are used along with the yolks of 50 eggs. After having warmed the alum bath through which the skins have been passed, the flower is dusted into it, with careful stirring. The paste is well kneaded by the gradual addition of the solution, and passed through the cullender, whereby it becomes as clear as honey. To this the yolks being added, the whole is incorporated with much manual labor. The skins are worked one after another in this paste; and afterwards the whole together are left immersed in it for a day. They are now stretched and dried upon poles, in a proper apartment, during from 8 to 15 days, according to the season.

The effects of the paste are to whiten the skins, to soften them, and to protect them from the hardening influence of the atmosphere, which would naturally render them brittle. They would not bear working upon the *softening iron*, but for the emulsion which has been introduced into their substance. With this view they are dipped in a tub of clear water during five or six minutes, and then spread and worked upon the board. They are increased by this means in length, in the proportion of 5 to 3. No hard points must be left in them. The whiteness is also better brought out by this operation, which is performed upon the flesh side. The softening tool is an iron plate, about one foot broad, rounded over above, mounted upon an upright beam, 30 inches high, which is fixed to the end of a strong horizontal plank, 3½ feet long, and 1 broad. This plank is heavily loaded, to make it immoveable upon the floor. Sometimes the skins are next spread over an undressed clean skin upon the horse, and worked well with the two-handled knife, for the purpose of removing the first and second epidermis, called the *fleur* and *arrière-fleur* by the French *megissiers*. They are then dried while stretched by hooks and strings. When dry they are worked on the *stretching iron*, or they are occasionally polished with pumice stone. A delicate yellow tint is given by a composition made of two parts of whitening, and one of ochre, applied in a moistened state, and well worked in upon the grain side. After being polished with pumice, they are smoothed with a hot iron, as the laundresses do linen, whereby they acquire a degree of lustre, and are ready to be delivered to the *glover*.

For *housings*, the best sheepskins are selected, and such as are covered with the longest and most beautiful fleece. They are steeped in water, in order to be cleansed and softened; after which they are thinned inside by the fleshing knife. They are now steeped in an old bran pit for 3 or 4 days, when they are taken out and washed. They are next subjected to the white or alum bath, the wool being carefully folded within; about 18 pounds of alum being used for 100 skins. The paste is made as for the fleeced skins, but it is merely spread upon their flesh side, and left upon them for 18 hours, so as to stiffen. They are then hung up to dry. They are next moistened by sprinkling cold water upon them, folded up, piled in a heap, and covered with boards weighted with heavy stones; in which state they remain for two days. They are next opened with a round iron upon the horse, and subjected to the stretching iron, being worked broadwise. They are dried with the fleece outermost, in the sun if possible; and are finished upon the *stretcher*.

Calf and lamb skins with their hair and wool are worked nearly in the same manner; only the thicker the skin, the stronger the alum bath ought to be. One pound of alum and one of salt are required for a single calf skin. It is left four days in this bath, after which it is worked upon the *stretcher*, then fulled; when half dry the skins are opened upon the horse. In eight days of ordinary weather, they may be completely dressed. Lamb skins are sometimes steeped during eight days in a bath prepared with unbolted rye flour and cold water, in which they are daily moved about two or three times. They are then dried, stretched upon the iron, and switched upon the fleecy side.

Chamois or *Shamoy leather.*—The skins are first washed, limed, fleeced, and branned as above described. They are next *efflowered*, that is, deprived of their epidermis by a concave knife, blunt in its middle part, upon the convex horse-beam. The cutting part serves to remove all excrescences, and to equalize the thickness, while the blunt part softens and smooths. The skins of goats, does, and chamois, are always treated in this way. They are next subjected to the fermenting bran steep for one or two days, in ordinary weather; but in hot weather for a much shorter time, sometimes only moving them in the sour bran liquor for a few minutes. They are lastly wrung at the peg, and subjected to the fulling mill.

When the skins have been sufficiently swelled and suppled by the branning, they may receive the first oil as follows: a dozen skins being stretched upon the table, the fingers are dipped in the oil, and shaken over the skins in different places, so as to impart enough of it to imbue the whole surface slightly, by friction with the palms of the hands. It is to the outside or *grain* that the oil is applied. The skins are folded four together, so as to form balls of the size of a hog's bladder, and thrown into the trough of the fulling mill, to the number of twelve dozen at once. Here they remain exposed to the beater for two, three, or four hours, according to their nature and the state of the weather. They are taken out, aired, oiled, and again fulled. The airing and fulling are repeated several times, with more or less frequent oilings. Any cheap animal oil is employed.

After these operations, the skins require to be subjected to a fermenting process, to dilate their pores, and to facilitate their combination with the oil. This is performed in a chamber only 6 feet high, and 10 or 12 feet square. Poles are suspended horizontally a few inches from the ceiling, with hooks fixed in them to which the skins are attached. A somewhat elevated temperature is maintained, and by a stove if need be. This operation requires great skill and experience.

The remainder of the epidermis is next removed by a blunt concave knife and the horse; whereby the surface is not cut, but rather forcibly scraped.

The skins are now scoured to carry off the redundant oil; which is effected by a potash ley, at two degrees Baumé, heated no hotter than the hand can bear. In this they are stirred briskly, steeped for an hour, and lastly wrung at the peg. The soapy liquor thus expelled is used for inferior purposes. The clean skins, after being dried, are finished first on the *stretcher-iron*, and then on the *herse* or stretching frame.

Leather of Hungary.—This is manufactured by impregnating strong hides with alum, common salt, and suet; by a rapid process which is usually completed in the space of two months. The workshop is divided into two parts: 1. A shed on the side of a stream, furnished with wooden horses, fleshing knives, and other small tools. In one corner is a furnace with a boiler for dissolving the alum, a vat for immersing the hides in the solution, and several subsidiary tubs. 2. A chamber, 6 feet high, by 15 feet square, capable of being made very tight, for preserving the heat. In one corner is a copper boiler, of sufficient size to contain 170 pounds of tallow. In the middle of the stove is a square stone slab, upon which an iron grate is placed about a yard square. This is covered with charcoal. At each side of the stove are large tables, which occupy its whole length, and on which the leather is spread to receive the grease. The upper part below the ceiling is filled with poles for hanging the leather upon to be heated. The door is made to shut perfectly close.

The first operations are analogous to those of tanning and tawing; the skins being washed, cut in halves, shaved, and steeped for 24 hours in the river. They are then cleaned with 5 or 6 pounds of alum, and 3½ pounds of salt, for a piece of hide which weighs from 70 to 80 pounds. The common salt softens the effect of the alum, attracts the moisture of the air, and preserves the suppleness of the skin. When the alum and salt are dissolved, hot water is poured upon the hides placed in a vat, and they are tramped upon by a workman walking repeatedly from one end of the vat to the other. They are then transferred into a similar vat containing some hot water, and similarly tramped upon. They are next steeped for eight days in alum water. The same round of operations is repeated a second time.

The skins are now dried either in the air, or a stove room; but before being quite dry, they are doubled together, well stretched to take out the wrinkles, and piled up. When dry, they are again tramped to open the pores as well as to render the skin pliant, after which they are whitened by exposure to the sun.

Tallow of inferior quality is employed for greasing the leather. With this view the hides are hung upon the poles in the close stove room, then laid upon the table, and besmeared with the tallow melted till it begins to crackle. This piece is laid on another table, is there covered with a second, similarly greased, and so forth. Three pounds of fat are commonly employed for one piece of leather.

When the thirty strips, or fifteen hides passed through the grease in one operation are completed, two workmen take the first piece in their hands, and stretch it over the burning charcoal on the grate for a minute, with the flesh side to the fire. The rest are passed over the flame in like manner. After *flaming*, the pieces are successively laid on an inclined table exposed to the fire, where they are covered with a cloth. They are finally hung upon poles in the air to dry; and if the weather be warm, they are suspended only during the night, so as to favor the hardening of the grease. Instead of the alum bath, M. Curaudau has employed with advantage a steep of dilute sulphuric acid.

Morocco leather.—The true morocco leather is goat skin tanned and then dyed on the side of the grain. Sheep skins are treated in the same way. The skins are steeped first in a fermenting mixture of bran water for a few days, they are then worked upon the horse, steeped in fresh water for 12 hours, and rinsed in the same. They are next drained, steeped in weak lime pits for a proper time, till the hairs can be readily detached. They are now subjected to the action of a blunt knife upon the horse-beam, in order to strip off their hair, after which they are cleansed in running water. Any excrescences must be carefully removed with the fleshing knife, and their edges neatly pared. The next process is rubbing them strongly with a piece of hard schist, set in a wooden frame, in order to expel by the pressure any lime which may still adhere, and to soften the grain. They are now worked upon the horse-beam with the blunt knife, and subjected to a species of fulling, by being agitated by pegs in a revolving cask along with water. Many manufacturers prefer a weak alkaline ley, or putrefied urine, to the lime bath.

The skins are immersed for a night and a day, in a bran bath, in a certain state of fermentation, then worked on the horse, and salted, to preserve them till they are to be dyed.

Preparatory to being dyed, each skin is sewed together edgewise, with the grain on the outside, and it is then mordanted either with a solution of tin, or with alum water. The color is given by cochineal, of which from 10 to 12 ounces are required for a dozen of skin. The cochineal being boiled in water along with a little tartar or alum for a few minutes, forms a red liquor, which is filtered through a linen cloth, and put into a clean cask. The skins are immersed in this bath, and agitated in it for about half an hour; they are taken out and beaten, and then subjected to a second immersion in the cochineal bath. After being thus dyed, they are rinsed and tanned with Sicilian sumach, at the rate of two pounds for a skin of moderate size. This process is performed in a large tub made of white wood, in the liquor of which the skins are floated like so many bladders, and moved about by manual labor during four hours. They are then taken out, drained, and again subjected to the tanning liquor; the whole process requiring a space of twenty-four hours. The skins are now unstitched, rinsed, fulled with beetles, drained, rubbed hard with a copper blade, and lastly hung up to dry.

Some manufacturers brighten the color by applying to the surface of the skins, in a damp state, a solution of carmine in ammonia with a sponge; others apply a decoction of saffron to enliven the scarlet tint. At Paris the morocco leather is tanned by agitation with a decoction of sumach in large casks made to revolve upon a horizontal axis, like a barrel churn. White galls are sometimes substituted for sumach; a pound being used for a skin. The skins must be finally cleaned with the utmost care.

The black dye is given by applying with the brush a solution of red acetate of iron to the grain side. Blue is communicated by the common cold indigo vat; violets, with a light blue followed by cochineal red; green, by Saxon blue followed by a yellow dye, usually made with the chopped roots of the barberry. This plant serves also for yellows. To dye olive, the skins are first passed through a weak solution of green vitriol, and then through the decoction of barberry root, containing a little Saxon blue. Puce color is communicated by logwood with a little alum; which may be modified by the addition of a little Brazil wood. In all these cases, whenever the skins are dyed, they should be rinsed, wrung or rather drained, stretched upon a table, then besmeared on the grain side with a film of linseed oil applied by means of a sponge, in order to promote their glossiness when curried, and to prevent them becoming horny by too rapid drying.

The last process in preparing morocco leather is the currying, which brings out the lustre, and restores the original suppleness. This operation is practised in different manners, according to the purpose the skins are to serve. For pocket-books, portfolios, and case making in general, they must be thinned as much as possible upon the flesh side, moistened slightly, then stretched upon the table, to smooth them; dried again, moistened, and lastly passed two or three times through the cylinder press in different directions, to produce the crossing of the grain. The skins intended for the shoemaker, the saddler, the bookbinder, &c., require more pliancy, and must be differently curried. After being thinned, they are glazed with a polisher while still moist, and a grain is formed upon the flesh side with the roughened lead plate or grainer of the curriers, called in French *pommelle;* they are glazed anew to remove the roughness produced by the pommel, and finally grained on the flesh side with a surface of cork applied under a pommel of white wood.

Russia leather.—The Russians have long been possessed of a method of making a peculiar leather, called by them *jucten*, dyed red with the aromatic saunders wood. This article has been much sought after, on account of not being subject to mould in damp situations, being proof against insects, and even repelling them from the vicinity of its odor. The skins are freed from the hair or fleece, by steeping in an ash-ley too weak to act upon the animal fibres. They are then rinsed, fulled for a longer or shorter time according to their nature, and fermented in a proper steep, after having been washed in hot water. They are taken out at the end of a week, but they may be steeped a second time if deemed necessary, to open their pores. They are now cleaned by working them at the horse on both the flesh and grain sides.

A paste is next composed, for 200 skins, of 38 pounds of rye flour, which is set to ferment with leaven. This dough is worked up with a sufficient quantity of water to form a bath for the skins, in which they are soaked for 48 hours; they are then transferred into small tubs, where they remain during fifteen days, after which they are washed at the river. These operations serve to prepare the skins for absorbing the astringent juices with uniformity. A decoction of willow bark (*salix cinerea* and *salix caprea*) being made, the skins are immersed in the boiler whenever the temperature of the liquor is sufficiently lowered not to injure the animal fibres, and handled and pressed for half an hour. This manipulation is repeated twice daily during the period of a week. The tanning infusion is then renewed, and applied to the same skins for another week; after which, being exposed to the air to dry, they are ready for being dyed, and then curried with the empyreumatic oil of the bark of the birch tree. To this substance the Russia leather owes its peculiarities. Many modes have been prescribed for preparing it; but the following is the one practised in Russia.

The whitish membranous epidermis of the birch, stripped of all woody parts, is introduced into an iron boiler, which, when stuffed full, is covered tight with a vaulted iron lid, having a pipe rising from its centre. A second boiler into which this pipe passes without reaching its bottom, is set over the first, and is luted to it at the edges, after the two are bolted together. They are then inverted, so that the upper one contains the birch bark. The under half of this apparatus is sunk in the earth, the surface of the upper boiler is coated over with a clay lute, then surrounded with a fire of wood, and exposed to a red heat, till the distillation be completed. This operation, though rude in appearance, and wasteful of wood, answers its purpose perfectly well. The iron cylinder apparatus used in Britain for distilling wood vinegar, would, however, be much more convenient and productive. When the above boilers are unluted, there is found in the upper one a very light powder of charcoal, and in the under one which served as a receiver, there is an oily, brown, empyreumatic fluid, of a very strong smell, which is mixed with the tar, and which floats over a small quantity of crude vinegar. The former matter is the oil employed to impregnate the skins, by working it into the flesh side with the currier's tools. It is difficult to make this oil penetrate with uniformity; and the Russians do not always succeed in this process, for they turn out many skins in a spotted state. This oil is at present obtained in France by distilling the birch bark in copper stills, and condensing the products by means of a pipe plunged in cold water. About 60 per cent. of the weight of the bark is extracted.

The skins imbibe this oil most equally before they are fully dry. Care must be taken not to apply too much of it, for fear of its passing through and staining the grain side of the leather. Chevreul has investigated the chemical nature of this odoriferous substance, and finding it to be a peculiar compound, has called it *betuline*.

LEDUM PALUSTRE. This plant is employed in Russia to tan the skins of goats, calves, and sheep, into a reddish leather of an agreeable smell; as also in the preparation of the oil of birch, for making what is commonly called Russia leather.

LEGUMINE is the name of a vegeto-alkali supposed to exist in leguminous plants.

LEMONS. See Citric Acid, and Oils, Essential.

LEVIGATION is the mechanical process whereby hard substances are reduced to a very fine powder.

LEUCITE is a hard Vesuvian mineral, consisting of silica, 54; alumina, 23; potash, 23.

LEUCINE is a white crystalline substance produced by acting upon flesh with sulphuric acid.

LEWIS is the name of one kind of shears used in cropping woollen cloth.

LIAS is a fine-grained argillaceous limestone, whose geological position is under the oolite; it is the proper lithographic stone.

LIBAVIUS, Liquor of, is the bichloride of tin, prepared by dissolving that metal, with the aid of heat, in *aqua regia*, or by passing chlorine gas through a solution of muriate of tin till no more gas be absorbed, evaporating the solution, and setting it aside to crystallize. The anhydrous bichloride is best prepared by mixing four parts of corrosive sublimate with one part of tin, previously amalgamated with just so much mercury as to render it pulverizable; and by distilling this mixture with a gentle heat. A colorless fluid, the dry bichloride of tin, or the proper fuming liquor of Libavius, comes over. When it is mixed with one third of its weight of water it becomes solid. The first bichloride of tin is used in calico-printing.

LICHEN. See Archil.

LIGNEOUS MATTER is vegetable fibre. See Fibrous Matter.

LIGNITE is one of the most recent geological formations, being the carbonaceous remains of forest trees. From this substance, as found in the neighborhood of Cologne, the brown colors, called *umber* and *earth of Cologne*, are prepared.

LILACH DYE. See Calico-printing and Dyeing.

LIMESTONE (*Calcaire*, Fr.; *Kalkstein*, Germ.), may be classed under the following heads:—

1. *Calcareous spar* occurs in colorless crystals or crystalline masses; dissolves with effervescence in muriatic acid; is scratched by soft iron, but not by the nail; specific gravity 2·7; loses 46 per cent. by the expulsion of carbonic acid, and calcines into quicklime.

2. *Calcsinter, or stalactitic carbonate of lime*, called also concretionary limestone, because formed of zones more or less undulated, and nearly parallel. These zones have a fibrous structure, arising from the successive deposites of the crystalline limestone from its solvent water. The long conical pieces called stalactites, show fibres converging to the axis. The tubercular consists of irregular lumps often sprinkled over with small crystals, and associated so as to exhibit the appearance of cauliflower. The stratiform, commonly called stalagmite, or alabaster limestone, represents zones not concentric, but spread out, waving, and parallel; its texture is sometimes lamellar, and sometimes fibrous. These waving strata are distinguishable from one another by their different densities, and by their degrees of translucency. This stalagmitic mass bears the name of oriental alabaster, when it is reddish-yellow with distinct zones, and is susceptible of a fine polish. Stalactites are formed in the large excavations of calcareous rocks. The water percolating down through them, and dropping from the roofs of the caverns, is usually charged with carbonate of lime held in suspension by an excess of carbonic acid. The exposure to air, the motion, and the consequent diminution of pressure, cause the precipitation of the carbonate of lime in the solid state. Each drop of water, on falling through the vault, abandons a small film of limestone, which enlarges by degrees, and forms either a cylinder or solid mass. This alabaster differs from marble in its parallel and waving layers, and its faint degree of transparency.

This alabaster serves for the decoration of public buildings, and is occasionally introduced into certain pieces of furniture. The fine Egyptian alabaster was anciently brought from the mountains of the Thebaid, between the Nile and the Red Sea, near a town called Alabastron, whence probably the name. Very fine red alabaster, of great hardness, was found at one time in the quarries of Montmartre, but the stock was soon exhausted.

The incrusting concretionary limestone differs little from the preceding except in the rapidity of its formation, and in being moulded upon some body whose shape it assumes. These deposites from calcareous springs, form equally on vegetable bodies, on stones, metals, within pipes of cast iron, wood, or lead. The incrustations on vegetable and animal substances are vulgarly called petrifactions, as the organic fibres are replaced by stone. One of the most curious springs of this nature is at the baths of Saint Philip, in Tuscany, where the water flows in almost a boiling state, over an enormous mass of alabaster which it has produced. The carbonate of lime seems to be held in solution here by sulphureted hydrogen, which flies off when the water issues to the day. Dr. Vegny has taken advantage of this property of the spring, to obtain basso-relievo figures of great whiteness and solidity. He makes use of sulphur moulds.

Calcareous tuf consists of similar incrustations made by petrifying rivulets running over mud, sand, vegetable remains, &c. It is porous, even cellular, somewhat soft, impure, and of a dirty gray color. Its surface is wavy, rough, and irregular. These incrustations or deposites are, however, sometimes so abundant, and the resulting stony matters so hard that buildings may be constructed with them. The stone with which the town of Pesti, in Italy, is built has been called *pipe-stone* by the Italians; and it has apparently derived its origin from incrustations upon large reeds.

The *travertino*, which served to construct all the monuments of Rome, appears to have been formed by the deposites of the Anio and the solfatara of Tivoli. The temples of Pæstum, which are of extreme antiquity, have been built with a *travertino* formed by the sediment of the waters which still flow in this territory. All these stones acquire great hardness in the air, and M. de Breislak thinks that it is to the happy union of travertino and pouzzolana in the same spot, that the monuments of Rome owe their great solidity.

Spongy limestone, usually called *Agaric mineral*, stone marrow, &c., belongs to this kind of formation. It has a very white color, a very fine grain, is soft to the touch, very tender, and light enough to float for an instant on water. It occurs in rather thin layers, in the crevices of calcareous rocks, and is so common in Switzerland as to be employed for whitening houses.

3. *Compact limestone*, is of a grain more or less fine, does not polish, nor afford large blocks free from fissures, has a conchoidal, or uneven scaly fracture. Colors very various. Its varieties are; *a*, The *sub-lamellar*, compact, with some appearance of a foliated texture. *b*, *Compact fine-grained limestone*, the zechstein of the Germans, to which M. Brongniart refers the lithographic stone in his classification of rocks (*Diction-*

naire des Sciences Naturelles), but the English geologists place the locality of the famous lithographic quarry of Solenhofen much higher in the plane of secondary superposition. Its fracture is conchoidal; color from gray to whitish; *c*, *Compact common limestone.* Grain of middle size; earthy aspect; uneven fracture; perfectly opaque; color, whitish to pale gray, yellow, or reddish. The limestones of the Jura formation are referred to this head, as well as most of those interspersed among the coal strata. *d*, The *coarse compact*, or Cornbrash; texture somewhat open, earthy aspect, rough to the touch, ragged fracture, color yellow, gray, or dirty red. *e*, *Compact cellular*, the Rauchekalk and Holekalk of the Germans, on account of the numerous holes or caverns distributed through it.

4. *Oolite or roe-stone.*—It consists of spherical grains of various size, from a millet seed, to a pea, or even an egg; texture compact; fracture even; colors, whitish, yellow, gray, reddish, brownish. The larger balls have almost always a foreign body for their centre or nucleus.

5. *Chalk;* texture earthy; grains fine, tender, friable; colors white, grayish, or pale yellowish.

6. *Coarse-grained limestone;* an earthy texture, in large particles, often loose; fracture foliated, uneven; color pale and dirty yellow. Coarse lias has been referred to this head.

7. *Marly limestone;* lake and fresh water limestone formation; texture fine-grained, more or less dense; apt to crumble down in the air; color white or pale yellow; fracture rough-grained, sometimes conchoidal; somewhat tenacious. Texture occasionally cavernous; with cylindrical winding cavities. This true limestone must not be confounded with the lime-marl, composed of calcareous matter and clay.

8. *Silicious limestone;* of a compact texture; scratching steel, and scratched by it; leaves a silicious residuum after the action of muriatic acid.

9. *Calp;* texture compact; fine-grained; schistose structure; hard, as the preceding; not burning into quicklime, affording to dilute muriatic acid a copious residuum of clay and silica; color blackish; found in beds in the transition district near Dublin.

10. *Lucullite* or stinkstone; texture compact or sub-lamellar, color grayish; emits the smell of sulphureted hydrogen by friction or a blow. It occurs at Assynt, in Sutherlandshire; in Derbyshire; counties of Kilkenny, Cork, and Galway.

11. *Bituminous limestone;* black or blackish color; diffusing by the action of fire a bituminous odor, and becoming white.

Of all common limestones the purity may most readily be determined by the quantity of carbonic acid which is evolved during their solution in dilute nitric or muriatic acid. Perfect carbonate of lime loses in this way 46 *per cent.;* and if any particular limestone loses only 23 *per cent.*, we may infer that it contains only one half its weight of calcareous carbonate. This method is equally applicable to *marls*, which are mixtures in various proportions of carbonate of lime, clay, and sand, and may all be recognised by their effervescing with acids.

The chief use of calcareous stones is for procuring quicklime by calcination in proper furnaces; and they are all adapted to this purpose provided they are not mixed with too large a proportion of sand and ferruginous clay, whereby they acquire a vitrescent texture in a high heat, and will not burn into lime. Limestone used to be calcined in a very rude kiln, formed by enclosing a circular space of 10 or 15 feet diameter, by rude stone walls 4 or 5 feet high, and filling the cylindrical cavity with alternate layers of turf or coal and limestone broken into moderate pieces. A bed of brushwood was usually placed at the bottom, to facilitate the kindling of the kiln. Whenever the combustion was fairly commenced, the top, piled into a conical form, was covered in with sods, to render the calcination slow and regular. This method being found relatively inconvenient and ineffectual, was succeeded by a permanent kiln built of stones or brickwork, in the shape of a truncated cone with the narrow end undermost, and closed at bottom by an iron grate. Into this kiln, the fuel and limestone were introduced at the top in alternate layers, beginning of course with the former; and the charge was either allowed to burn out, when the lime was altogether removed at a door near the bottom, or the kiln was successively fed with fresh materials, in alternate beds, as the former supply sunk down by the calcination, while the thoroughly burnt lime at the bottom was successively raked out by a side door immediately above the grate. The interior of the lime kiln has been changed of late years from the conical to the elliptical form; and probably the best is that of an egg placed with its narrow end undermost, and truncated both above and below; the ground plot or bottom of the kiln being compressed so as to give an elliptical section, with an *eye* or draft-hole towards each end of that ellipse. A kiln thus arched in above gives a reverberatory heat to the upper materials, and also favors their falling freely down in proportion as the finished lime is raked out below; advantages which the conical form does not afford. The size of the draft-notes for extracting the quicklime, should be proportionate to the size of the kiln, in order to admit a sufficient current of air to ascend with the smoke and flame, which is found to facilitate the extrication of the carbonic acid. The kilns are called *perpetual*, because the operation is carried on continuously as long as the building lasts; and *draw-kilns*, from the mode of discharging them by raking out the lime into carts placed against the draft-holes. Three bushels of calcined limestone, or lime-shells, are produced on an average for every bushel of coals consumed. Such kilns should be built up against the face of a cliff, so that easy access may be gained to the mouth for charging, by making a sloping cart road to the top of the bank.

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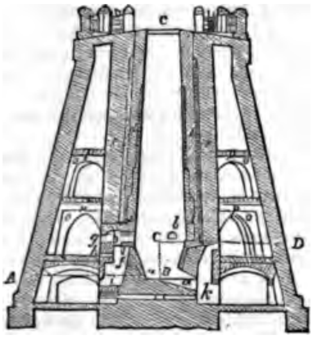

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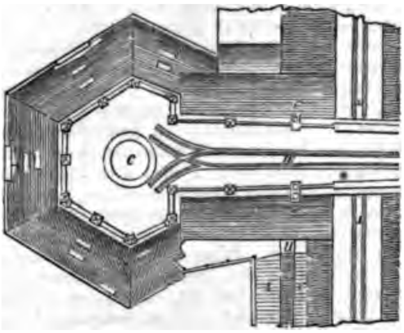

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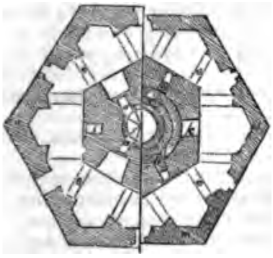

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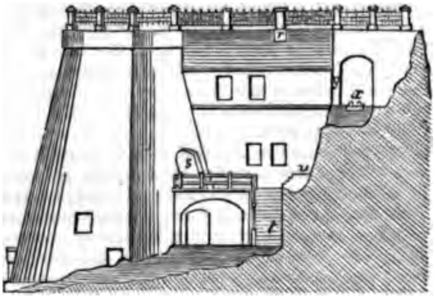


Figs. 638, 639, 640, 641, represent the *lime-kiln* of Rüdersdorf near Berlin, upon the continuous plan, excellently constructed for economizing fuel. It is triple, and yields a threefold product. *Fig.* 640, is a view of it as seen from above; *fig.* 641, the elevation and general appearance of one side; *fig.* 638, a vertical section, and *fig.* 639, the ground plan in the line A B C D of *fig.* 638. The inner shaft *fig.* 638, has the form of two truncated cones, with their larger circular ends applied to each other; it has the greatest width at the level of the fire-door *b*, where it is 8 feet in diameter; it is narrower below at the discharge door, and at the top orifice, where it is about 6 feet in diameter. The interior wall *d*, of the upper shaft is built with hewn stones, to the height of 38 feet, and below that for 25 feet, with fire-bricks *d′ d′*, laid stepwise. This inner wall is surrounded with a mantle *e*, of limestones, but between the two there is a small vacant space of a few inches filled with ashes, in order to allow of the expansion of the interior with heat taking place without shattering the mass of the building.

The fire-grate *b*, consists of fire-tiles, which at the middle, where the single pieces press together, lie upon an arched support *f*. The fire-door is also arched, and is secured by fire-tiles. *g* is the iron door in front of that orifice. The tiles which form the grate have 3 or 4 slits of an inch wide for admitting the air, which enters through the canal *h*. The under part of the shaft from the fire to the hearth, is 7 feet, and the outer enclosing wall is constructed of limestone, the lining being of fire-bricks. Here are the ash-pit *i*, the discharge outlet *a*, and the canal *k*, in front of the outlet. Each ash-pit is shut with an iron door, which is opened only when the space *i* becomes filled with ashes. These indeed are allowed to remain till they get cool enough to be removed without inconvenience.

The discharge outlets are also furnished with iron doors, which are opened only for taking out the lime, and are carefully luted with loam during the burning. The outer walls *l m n* of the kiln, are not essentially necessary, but convenient, because they afford room for the lime to lie in the lower floor, and the fuel in the second. The several stories are formed of groined arches *o*, and platforms *p*, covered over with limestone slabs. In the third and fourth stories the workmen lodge at night. See *fig.* 641. Some enter their apartments by the upper door *q*; others by the lower door *s*. *r* is one of the chimneys for the several fire-places of the workmen. *t u v* are stairs.

As the limestone is introduced at top, the mouth of the kiln is surrounded with a strong iron balustrade to prevent the danger of the people tumbling in. The platform is laid with rails *w*, for the wagons of limestone, drawn by horses, to run upon. *x* is another rail-way, leading to another kiln. Such kilns are named after the number of their fire-doors, single, twofold, threefold, fourfold, &c.; from three to five being the most usual. The outer form of the kiln also is determined by the number of the furnaces; being a truncated pyramid of equal sides; and in the middle of each alternate side there is a fire-place, and a discharge outlet. A cubic foot of limestone requires for burning, one and five twelfths of a cubic foot of wood, and one and a half of turf.

When the kiln is to be set in action, it is filled with rough limestones, to the height C D, or to the level of the firing; a wood fire is kindled in *a*, and kept up till the lime is calcined. Upon this mass of quicklime, a fresh quantity of limestones is introduced, not thrown in at the mouth, but let down in buckets, till the kiln be quite full; while over the top a cone of limestones is piled up, about 4 feet high. A turf-fire is now kindled in the furnaces *b*. Whenever the upper stones are well calcined, the lime under the fire-level is taken out, the superior column falls in, a new cone is piled up, and the process goes on thus without interruption, and without the necessity of once putting a fire into *a*; for in the space C B, the lime must be always well calcined. The discharge of lime takes place every 12 hours, and it amounts at each time in a threefold kiln, to from 20 to 24 Prussian *tonnes* of 6 imperial bushels each; or to 130 bushels imperial upon the average. It is found by experience, that fresh-broken limestone which contains a little moisture, calcines more readily than what has been dried by exposure for some time to the air; in consequence of the vapor of water promoting the escape of the carbonic acid gas; a fact well exemplified in distilling essential oils, as oil of turpentine and naptha, which come over with the steam of water, at upwards of 100 degrees F. below their natural term of ebullition. Six bushels of Rudersdorf quicklime weigh from 280 to 306 pounds.

When coals are used for fuel in a well-constructed perpetual, or draw kiln, about 1 measure of them should suffice for 4 or 5 of limestone.

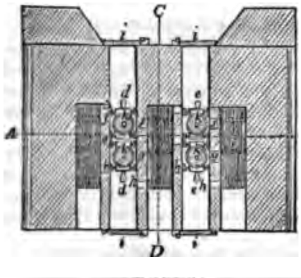
The most extensive employment of quicklime is in agriculture, on which subject instructive details are given in Loudon's Encyclopædias of Agriculture and Gardening.

Quicklime is employed in a multitude of preparations subservient to the arts; for clarifying the juice of the sugar-cane and the beet-root; for purifying coal gas; for rendering the potash and soda of commerce caustic in the soap manufacture, and in the bleaching of linen and cotton; for purifying animal matters before dissolving out their gelatine; for clearing hides of their hair in tanneries; for extracting the pure volatile alkali from muriate or sulphate of ammonia; for rendering confined portions of air very dry; for stopping the leakage of stone reservoirs, when mixed with clay and thrown into the water; for making a powerful lute with white of egg or serum of blood; for preparing a depilatory pommade with sulphuret of arsenic, &c. Lime water is used in medicine, and quicklime is of general use in chemical researches. Next to agriculture the most extensive application of quicklime is to MORTAR-CEMENTS, which see.

LINEN. See FLAX, and TEXTILE FABRICS.

LINSEED (*Graine de lin*, Fr.; *Leinsame*, Germ.) contains, in its dry state, 11·265 of oil; 0·146 of wax; 2·488 of a soft resin; 0·550 of a coloring resinous matter; 0·926 of a yellowish substance analogous to tannin; 6·154 of gum; 15·12 of vegetable mucilage; 1·48 of starch; 2·932 of gluten; 2·782 of albumine; 10·884 of saccharine extractive; 44·382 of envelopes, including some vegetable mucilage. It contains also free acetic acid; some acetate, sulphate, and muriate of potash, phosphate and sulphate of lime; phosphate of magnesia; and silica. See OILS, UNCTUOUS.

LIQUATION (Eng. and Fr.; *Saigerung*, Germ.) is the process of sweating out, by a regulated heat, from an alloy, an easily fusible metal from the interstices of a metal difficult of fusion. Lead and antimony are the metals most commonly subjected to liquation; the former for the purpose of carrying off by a superior affinity the silver present in any complex alloy, a subject discussed under SILVER; the latter will be considered here, as referred to from the article ANTIMONY.



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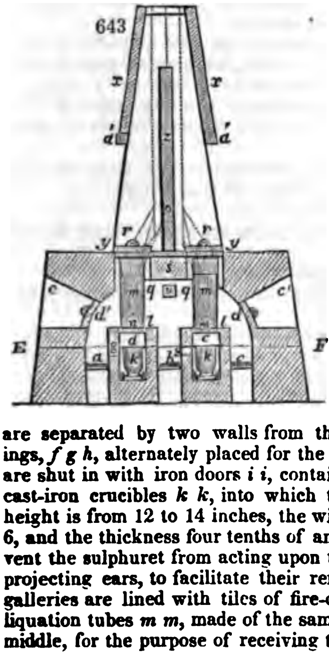

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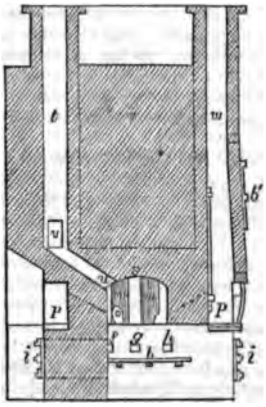


Figs. 642, 643, 644, represent the celebrated antimonial liquation furnaces of Malbosc, in the department of Ardèche, in France. *Fig.* 642 is a ground plan taken at the level of the draught holes *g g*, *fig.* 643, and of the dotted line E F; *fig.* 643 is a vertical section through the dotted line A B, of *fig.* 642; and *fig.* 644 is a vertical section through the dotted line C D of *fig.* 642. In the three figures, the same letters denote like objects. *a b c* are three grates upon the same level above the floor of the works, 4½ feet long, by 10½ inches broad; between which are two rectangular galleries, *d e*, which pass transversely through the whole furnace, and lie at a level of 12 inches above the ground. They are separated by two walls from the three fire-places. The walls have three openings, *f g h*, alternately placed for the flames to play through. The ends of these galleries are shut in with iron doors *i i*, containing peep holes. In each gallery are two conical cast-iron crucibles *k k*, into which the *eliquating* sulphuret of antimony drops. Their height is from 12 to 14 inches, the width of the mouth is 10 inches, that of the bottom is 6, and the thickness four tenths of an inch. They are coated over with fire-clay, to prevent the sulphuret from acting upon them; and they stand upon cast-iron pedestals with projecting ears, to facilitate their removal from the gallery or platform. Both of these galleries are lined with tiles of fire-clay *l l*, which also serve as supports to the vertical liquation tubes *m m*, made of the same clay. The tiles are somewhat curved towards the middle, for the purpose of receiving the lower ends of these tubes, and have a small hole at *n*, through which the liquid sulphuret flows down into the crucible.

The liquation tubes are conical, the internal diameter at top being 10 inches, at bottom 8; the length fully 40 inches, and the thickness six tenths of an inch. They have at their lower ends notches or slits *o*, *fig.* 644, from 3 to 5 inches long, which look outwards, to make them accessible from the front and back part of the furnaces through small conical openings *p p*, in the walls. These are closed during the operation with clay stoppers, and are opened only when the gangue, rubbish, and cinders are to be raked out. The liquation tubes pass across the arch of the furnace *q q*, the space of the arch being wider than the tubes; they are shut in at top with fire-covers *r r*. *s s*, the middle part of the arch, immediately under the middle grate, is barrel-shaped, so that both arches are abutted together. The flames, after playing round about the sides of the liquation tubes, pass off through three openings and flues into the chimney *t*, about 13 feet high; *u* being the one opening, and *v* the two others, which are provided with register plates. In front of the furnace is a smoke flue *w*, to carry off the sulphureous vapors exhaled during the clearing out of the rubbish and slag; another, *x*, begins over *y y*, at the top of the tubes; a wall *z*, separates the smoke flue into halves, so that the workmen upon the one side may not be incommoded by the fumes of the other. This wall connects at the same time the front flue *w* with the chimney *t*. *a' a'* and *b' b'* are iron and wooden bearer beams and rods for strengthening the smoke-flue. *c' c'* are arches upon both sides of the furnace, which become narrower from without inwards, and are closed with well-fitted plates *d' d'*. They serve, in particular circumstances, to allow the interior to be inspected, and to see if either of the liquation furnaces be out of order.

Each tube being charged with about 500 lbs. of the antimonial ore, previously warmed upon the roof of the furnace, in a short time the sulphuret of a blue color begins to flow out. Whenever the liquation ceases, the cinders are raked out by the side openings, and the tubes are charged afresh. The luted iron crucibles are suffered to become three fourths full, are then drawn out from the galleries, left to cool, and emptied. The ingots weigh about 85 pounds. The charging is renewed every three hours, and, when the process is in good train, 100 lbs. of sulphuret of antimony are obtained every hour. The average duration of the tubes is 3 weeks, though in some cases it may be 40 days. The product from the ore is from 40 to 50 per cent. The above plan of operation is remarkable for the small consumption of fuel, the economy of labor, and the complete exhaustion of the ore.

LIQUEURS, LIQUORISTE; names given by the French to liquors compounded of alcohol, water, sugar, and different aromatic substances; and to the person who compounds them. I shall insert here a few of their most approved recipes.

Infusion of the peels of fruits.—The outer skin, pared off with a sharp knife, is to be dropped into a hard glazed jar, containing alcohol of 34° B., diluted with half its bulk of water, and the whole is to be transferred into well-corked carboys. After an infusion of six weeks, with occasional agitation, the aromatized spirit is to be distilled off. In this way are prepared the liquors of cedrat, lemons, oranges, *limettes* (a sort of sweet lemon), *poncires* (the large citron), bergamots, &c.

Infusion of aromatic seeds.—These must be pounded, put into a carboy, along with alcohol diluted as above, infused with agitation for six weeks, and then distilled.

Infusions of aromatic woods are made in the same way.

The liquorist should not bring his infusions and tinctures into the market till six months after their distillation.

Liqueurs have different titles, according to their mode of fabrication.

Thus *waters* are liquors apparently devoid of viscidity; *creams* and *oils* possess it in a high degree.

Water of *cedrat*, is made by dissolving six pounds of sugar in seven quarts of water; adding two quarts of spirit of *cedrat*, and one of spirit of citron. Boil the whole for a minute, and filter hot through a proper bag. Set it for a considerable time aside in a corked carboy, before it be bottled.

Oil or cream of cedrat.—Take eight quarts of river water, two of spirit of cedrat, one of spirit of citron, and as much rich sirup as is necessary to give the mixture an oily consistence. Stir it well and set it aside in carboys. Should it be at all clouded, it must be filtered till it be perfectly pellucid.

Balm of Molucca, is made by infusing for ten days, in a carboy capable of holding fully four gallons, 10 pounds of spirits of 18° B., 4 pounds of white sugar, 4 pounds of river water, 4 drachms of pounded cloves, and 48 grains of pounded mace. The mixture is to be shaken 3 or 4 times daily, colored with caramel (burnt sugar), filtered at the end of ten days, and set aside in bottles.

Tears of the widow of Malabar, are compounded with the preceding quantity of spirits, sugar, and water, adding 4 drachms of ground cinnamon, 48 grains of cloves, and a like quantity of mace, both in powder. It may be slightly colored with caramel.

The delight of the Mandarins.—Take spirit, sugar, and water, as above, adding 4 drachms of *anisum Chinæ*, (*Gingi*), as much *ambrette* (seeds of the *hibiscus abelmoschus*, *Lin.*), all in powder; 2 drachms of safflower.

The sighs of love.—Take spirits, water, and sugar, as above. Perfume with essence (otto) of roses; give a very pale pink hue with tincture of cochineal, filter and bottle up.

Crême de macarons.—Add to the spirit, sugar, and water as above, half a pound of bitter almonds, blanched and pounded; cloves, cinnamon, and mace in powder, of each 48 grains. A violet tint is given by the tinctures of turnsole and cochineal.

Curacoa.—Put into a large bottle nearly full of alcohol of *trente-six* (34° Baumé), the peels of six smooth Portugal oranges, (Seville ?) and let them infuse for 15 days; then put into a carboy 10 pounds of spirits of 18° B., 4 pounds of white sugar, and 4 pounds of river water. When the sugar is dissolved, add a sufficient quantity of the orange *zestes* to give flavor, then spice the whole with 48 grains of cinnamon, and as much mace, both in powder. Lastly introduce an ounce of ground Brazil wood, and infuse during 10 days, agitating 3 or 4 times daily. A pretty deep hue ought to be given with caramel.

Swiss extract of wormwood is compounded as follows:—

Tops of the absinthium majus 4 pounds;
Ditto, absinthium minus 2 pounds;

Roots of angelica,
Calamus aromaticus,
Seeds of the *anisum Chinæ*,
Leaves of the dittany of Crete,
} of each a few grains at pleasure;
Alcohol of 20° B., four gallons Imp.

Macerate these substances during eight days, then distil by a gentle fire; draw off two gallons of spirits, and add to it 2 drachms of essential oil of anise-seed. The two gallons left in the still serve for preparing the *vulnerary spirituous water*.

Of coloring the *liqueurs*.

Yellow is given with the yellow coloring matter of safflower (*carthamus*), which is readily extracted by water.

Fawn is given by *caramel*, made by heating ground white sugar in an iron spoon over a charcoal fire, till it assumes the desired tint, and then pouring it into a little cold water.

Red is given by cochineal alone, or with a little alum.

Violet is given by good litmus (turnsole).

Blue and *green*.—Sulphate of indigo gives the first. After saturating it nearly with chalk, alcohol being digested upon it, becomes blue. This tincture mixed with that of carthamus forms a good green.

LIQUID AMBER is obtained from the *liquidambar styraciflua*, a tree which grows in Mexico, Louisiana, and Virginia. Some specimens are thin, like oil, and others are thickish, like turpentine. It is transparent, amber colored, has an agreeable and powerful smell, and an aromatic taste, which feels pungent in the throat. Boiling alcohol dissolves it almost entirely. It contains a good deal of benzoic acid, some of which effloresces whenever the liquid amber hardens with keeping.

LITHARGE (Eng. and Fr.; *Glätte*, Germ.) is the fused yellow protoxyde of lead, which on cooling passes into a mass consisting of small six-sided plates, of a reddish yellow color, and semi-transparent. It generally contains more or less red lead, whence the variations of its color; and carbonic acid, especially when it has been exposed to the air for some time. See Lead and Silver, for its mode of preparation.

LITHIA is a simple earthy or alkaline substance, discovered not many years ago, in the minerals called petalite and triphane. It is white, very caustic, reddens litmus and red cabbage, and saturates acids with great facility. When exposed to the air it attracts humidity and carbonic acid. It is more soluble in water than baryta; and has such a strong affinity for it, as to be obtained only in the state of a hydrate. It forms neutral salts with all the acids. It is most remarkable for its power of acting upon, or corroding platinum.

LITHIUM is the metallic basis of Lithia; the latter substance consists of 100 of metal, and 123 of oxygen.

LITHOGRAPHY. Though this subject belongs rather to the arts of taste and design than to productive manufactures, its chemical principles fall within the province of this Dictionary.

The term *lithography* is derived from λιθος, *a stone*, and γραφη, *writing*, and designates the art of throwing off impressions, upon paper, of figures and writing previously traced upon stone. The processes of this art are founded:—

1. Upon the adhesion to a smoothly polished limestone of an encaustic fat which forms the lines or traces.
2. Upon the power, acquired by the parts penetrated by this encaustic, of attracting to themselves, and becoming covered with a printer's ink, having linseed oil for its basis.
3. Upon the interposition of a film of water, which prevents the adhesion of the ink in all the parts of the surface of the stone not impregnated with the encaustic.
4. Lastly, upon a pressure applied by the stone, such as to transfer to paper the greater part of the ink which covers the greasy tracings of the encaustic.

The lithographic stones of the best quality are still procured from the quarry of Solenhofen, a village at no great distance from Munich, where this mode of printing had its birth. They resemble in their aspect the yellowish white lias of Bath, but their geological place is much higher than the lias. Abundant quarries of these fine-grained limestones occur in the county of Pappenheim, along the banks of the Danube, presenting slabs of every required degree of thickness, parted by regular seams, and ready for removal with very little violence. The good quality of a lithographic stone is generally denoted by the following characters: its hue is of a yellowish gray, and uniform throughout; it is free from veins, fibres, and spots; a steel point makes an impression on it with difficulty; and the splinters broken off from it by the hammer display a conchoidal fracture.

The Munich stones are retailed on the spot in slabs or layers of equal thickness; they are quarried with the aid of a saw, so as to sacrifice as little as possible of the irregular edges of the rectangular tables or plates. One of the broad faces is then dressed and coarsely smoothed. The thickness of these stones is nearly proportional to their other dimensions; and varies from an inch and two thirds to 3 inches.

In each lithographic establishment, the stones receive their finishing, dressing, and polishing; which are performed like the grinding and polishing of mirror plate. The work is done by hand, by rubbing circularly a moveable slab over another cemented in a horizontal position, with fine sifted sand and water interposed between the two. The style of *work* that the stone is intended to produce determines the kind of polish that it should get. For crayon drawing the stone should be merely grained more or less *fine*, according to the fancy of the draughtsman. The higher the finish of the surface, the softer are the drawings; but the printing process becomes sooner *pasty*, and a smaller number of impressions can be taken. *Works in ink* require the stone to be more softened down, and finally polished with pumice and a little water. The stones thus prepared are packed for use with white paper interposed between their faces.

Lithographic crayons.—Fine lithographic prints cannot be obtained unless the crayons possess every requisite quality. The ingredients composing them ought to be of such a nature as to adhere strongly to the stone, both after the drawing has undergone the preparation of the acid, and during the press-work. They should be hard enough to admit of a fine point, and trace delicate lines without risk of breaking. The following composition has been successfully employed for crayons by MM. Bernard and Delarue, at Paris:—

Pure wax, (first quality) - -	4
Dry white tallow soap - - -	2
White tallow - - - - -	2
Gum lac - - - - -	2
Lamp black, enough to give a dark tint	1
Occasionally copal varnish - -	1

The wax is to be melted over a gentle fire, and the lac broken to bits is then to be added by degrees, stirring all the while with a spatula; the soap is next introduced in fine shavings; and when the mixture of these substances is very intimately accomplished, the copal-varnish, incorporated with the lamp black, is poured in. The heat and agitation are continued till the paste has acquired a suitable consistence; which may be recognised by taking out a little of it, letting it cool on a plate, and trying its quality with a penknife. This composition, on being cut, should afford brittle slices. The boiling may be quickened by setting the rising vapors on fire, which increases the temperature, and renders the exhalations less offensive. When ready, it is to be poured into a brass mould, made of two semi-cylinders joined together by clasps or rings, forming between them a cylindric tube of the crayon size. The mould should be previously smeared with a greasy cloth.

M. Lasteyrie prescribes a more simple composition, said to be equally fit for the lithographer's use:—

Dried white tallow soap - - -	6 parts.
White wax - - - - - - -	6 —
Lamp black - - - - - - -	1 —

The soap and tallow are to be put into a small goblet and covered up. When the whole is thoroughly fused by heat, and no clots remain, the black is gradually sprinkled in with careful stirring.

Lithographic ink is prepared nearly on the same principles:—

Wax - - - - - - - -	16 parts.
Tallow - - - - - -	6 —
Hard tallow soap - - - - -	6 —
Shellac - - - - - -	12 —
Mastic in tears - - - - -	8 —
Venice turpentine - - -	1 —
Lamp black - - - - - -	4 —

The mastic and lac, previously ground together, are to be heated with care in the turpentine; the wax and tallow are to be added after they are taken off the fire, and when their solution is effected, the soap shavings are to be thrown in. Lastly, the lamp black is to be well intermixed. Whenever the union is accomplished by heat, the operation is finished; the liquor is left to cool a little, then poured out on tables, and, when cold, cut into square rods.

Lithographic ink of good quality ought to be susceptible of forming an emulsion so attenuated, that it may appear to be dissolved when rubbed upon a hard body in dis tilled or river water. It should be flowing in the pen, not spreading on the stone; capable of forming delicate traces, and very black to show its delineations. The most essential quality of the ink is to sink well into the stone, so as to re-produce the most delicate outlines of the drawing, and to afford a great many impressions. It must therefore be able to resist the acid with which the stone is moistened in the preparation, without letting any of its greasy matter escape.

M. de Lasteyrie states that after having tried a great many combinations, he gives the preference to the following:—

Tallow soap, dried - - - - - -	30 parts
Mastic, in tears - - - - - -	30 —
White soda of commerce - - -	30 —
Shellac - - - - - - - -	150 —
Lamp-black - - - - - - - -	12 —

The soap is first put into the goblet and melted over the fire, to which the lac being added fuses immediately; the soda is then introduced, and next the mastic, stirring all the while with a spatula. A brisk fire is applied till all these materials be melted completely, when the whole is poured out into the mould.

The inks now prescribed may be employed equally with the pen and the hair pencil, for writings, black-lead drawings, *aqua tinta*, mixed drawings, those which represent engravings on wood (wood cuts), &c. When the ink is to be used it is to be rubbed down with water, in the manner of China ink, till the shade be of the requisite depth. The temperature of the place ought to be from 84° to 90° Fahr., or the saucer in which the ink-stick is rubbed should be set in a heated plate. No more ink should be dissolved than is to be used at the time, for it rarely keeps in the liquid state for 24 hours; and it should be covered or corked up.

Autographic paper.—Autography, or the operation by which a writing or a drawing is transferred from paper to stone, presents not merely a means of abridging labor, but also that of *re*verting the writings or drawings into the direction in which they were traced, whilst, if executed directly upon the stone, the impression given by it is *in*verted. Hence, a writing upon stone must be inverted from right to left to obtain direct impressions. But the art of writing thus is tedious and difficult to acquire, while, by means of the autographic paper and the transfer, proofs are obtained in the same direction with the writing and drawing.

Autographic ink.—It must be fatter and softer than that applied directly to the stone, so that though dry upon the paper, it may still preserve sufficient viscidity to stick to the stone by mere pressure.

To compose this ink, we take—

White soap - - - - - - - -	100 parts
White wax of the best quality - -	100 —
Mutton suet - - - - - - -	30 —
Shellac - - - - - - - -	50 —
Mastic - - - - - - - - -	50 —
Lamp-black - - - - - -	30 or 35 —

These materials are to be melted as above described for the lithographic ink.

Lithographic ink and paper.—The following recipes have been much commended:—

Virgin or white wax - - - - - -	8 parts
White soap - - - - - - - -	2 —
Shellac - - - - - - - - -	2 —
Lamp-black - - - - - - - -	3 table-spoonsful.

Preparation.—The wax and soap are to be melted together, and before they become so hot as to take fire, the lamp-black is to be well stirred in with a spatula, and then the mixture is to be allowed to burn for 30 seconds; the flame being extinguished, the lac is to be added by degrees, carefully stirring all the time; the vessel is to be put upon the fire once more in order to complete the combination, and till the materials are either kindled or nearly so. After the flame is extinguished, the ink must be suffered to cool a little, and then put into the moulds.

With the ink crayons thus made, lines may be drawn as fine as with the point of the graver, and as full as can be desired, without risk of its spreading in the carriage. Its traces will remain unchanged on paper for years before being transferred.

Some may think it strange that there is no suet in the above composition, but it has been found that ink containing it is only good when used soon after it is made, and when immediately transferred to the stone, while traces drawn on paper with the suet ink become defective after 4 or 5 days.

Lithographic paper.—Lay on the paper, 3 successive coats of sheep-feet jelly,
1 layer of white starch,
1 layer of gamboge.

The first layer is applied with a sponge dipped in the solution of the hot jelly, very equally over the whole surface, but thin; and if the leaf be stretched upon a cord, the gelatine will be more uniform. The next two coats are to be laid on, until each is dry. The layer of starch is then to be applied with a sponge, and it will also be very thin and equal. The coat of gamboge is lastly to be applied in the same way. When the paper is dry, it must be smoothed by passing it through the lithographic press; and the more polished it is, the better does it take on the ink in fine lines.

Transfer.—When the paper is moistened, the transfer of the ink from the gamboge is perfect and infallible. The starch separates from the gelatine, and if, after taking the paper off the stone, we place it on a white slab of stone, and pour hot water over it, it will resume its primitive state.

The coat of gamboge ought to be laid on the same day it is dissolved, as by keeping it becomes of an oily nature; in this state it does not obstruct the transfer, but it gives a gloss to the paper which renders the drawing or tracing more difficult, especially to persons little habituated to lithography.

The starch paste can be employed only when cold, the day after it is made, and after having the skin removed from its surface.

A leaf of such lithographic paper may be made in two minutes.

In transferring a writing, an ink drawing, or a lithographic crayon, even the impression of a copper-plate, to the stone, it is necessary, 1. that the impressions be made upon a thin and slender body like common paper; 2. that they may be detached and fixed totally on the stone by means of pressure; but as the ink of a drawing sinks to a certain depth in paper, and adheres pretty strongly, it would be difficult to detach all its parts, were there not previously put between the paper and the traces, a body capable of being separated from the paper, and of losing its adhesion to it by means of the water with which it is damped. In order to produce this effect, the paper gets a certain preparation, which consists in coating it over with a kind of paste ready to receive every delineation without suffering it to penetrate into the paper. There are different modes of communicating this property to paper. Besides the above, the following may be tried. Take an unsized paper, rather strong, and cover it with a varnish composed of:—

Starch	120 parts
Gum arabic	40 —
Alum	20 —

A paste of moderate consistence must be made with the starch and some water, with the aid of heat, into which the gum and alum are to be thrown, each previously dissolved in separate vessels. When the whole is well mixed, it is to be applied, still hot, on the leaves of paper, with a flat smooth brush. A tint of yellow color may be given to the varnish, with a decoction of the berries of Avignon, commonly called French berries by our dyers. The paper is to be dried, and smoothed by passing under the scraper of the lithographic press.

Steel pens are employed for writing and drawing with ink on the lithographic stones.

LITMUS (*Tournesol*, Fr.; *Lackmus*, Germ.) is prepared in Holland from the species of lichen called *Lecanora tartarea*, *Roccella tartarea*, by a process which has been kept secret, but which is undoubtedly analogous to that for making archil and cudbear. The ground lichens are first treated with urine containing a little potash, and allowed to ferment, whereby they produce a purple-red; the colored liquor, treated with quicklime and some more urine, is set again to ferment during two or three weeks, then it is mixed with chalk or gypsum into a paste, which is formed into small cubical pieces, and dried in the shade. Litmus has a violet-blue color, is easy to pulverize, is partially soluble in water and dilute alcohol, leaving a residuum consisting of carbonate of lime, of clay, silica, gypsum, and oxyde of iron combined with the dye. The color of litmus is not altered by alkalis, but is reddened by acids; and is therefore used in chemistry as a delicate test of acidity, either in the state of solution or of unsized paper stained with it. It is employed to dye marble blue.

LIXIVIATION (*Lessivage*, Fr.; *Auslagen*, Germ.) signifies the abstraction by water of the soluble alkaline or saline matters present in any earthy admixture; as from that of quicklime and potashes to make potash ley, from that of effloresced alum schist to make aluminous liquors, &c.

LOADSTONE, MAGNETIC IRON-STONE (*Fer oxydulé*, Fr.; *Magneteisen-*

stein, Germ.); an iron ore consisting of the protoxyde and peroxyde of iron in a state of combination

LOAM (*Terre-limoneuse*, Fr.; *Lehm*, Germ.); a native clay mixed with quartz sand and iron ochre, and occasionally with some carbonate of lime.

LODE, is the name given by the Cornish miners to a vein, whether it be filled with metallic or earthy matter.

LOGWOOD (*Bois de Campèche*, *Bois bleu*, Fr.; *Blauholz*, Germ.) is the wood of the *Hæmatoxylon Campechianum*, a native tree of central America, grown in Jamaica since 1715. It was first introduced into England in the reign of Elizabeth, but as it afforded to the unskilful dyers of her time a fugitive color, it was not only prohibited from being used, under severe penalties, but was ordered to be burned wherever found, by a law passed in the 23d year of her reign. The same prejudice existed, and the same law was enacted against indigo. At length, after a century of absurd prohibition, these two most valuable tinctorial matters, by which all our hats, and the greater part of our woollen cloths, are dyed, were allowed to be used.

Old wood, with black bark and with little of the white alburnum, is preferred. Logwood is denser than water, very hard, of a fine compact grain, and almost indestructible by the atmospheric elements; it has a sweet and astringent taste, and a peculiar not inoffensive smell.

For its chemical composition, see Hematin.

When chipped logwood is for some time exposed to the air, it loses a portion of its dyeing power. Its decoction absorbs the oxygen of the atmosphere, and then acquires the property of precipitating with gelatine, which it had not before. The dry extract of logwood, made from an old decoction, affords only a fugitive color.

For its applications in dyeing, see Black Dye; Brown Dye; Calico Printing; Dyeing; Hat Dyeing, &c.

The imports of logwood for home use were, in 1836, 12,880 tons, 13 cwts.; in 1837, 14,677 tons, 13 cwts. And the amount of duty received was, in 1836, 2,480*l.*; in 1837, 2,552*l.*

LOOM (*Metier à tisser*, Fr.; *Weberstuhl*, Germ.) is the ancient and well-known machine for weaving cloth by the decussation of a series of parallel threads, which run lengthwise, called the warp or chain, with other threads thrown transversely with the shuttle, called the woof or weft. See Jacquard Loom and Weaving.

LUBRICATION. The following simple and efficacious plan of lubricating the joints and bearings of machinery by capillary attraction, has been kindly communicated to me by its ingenious inventor, Edward Woolsey, Esq.: —

Fig. 645, represents a tin cup, which has a small tin tube A, which passes through the bottom, as shown by the dotted lines. It may have a tin cover to keep out the dust.

Fig. 646, is a plan of the same.

Fig. 647, is a section of the same. Oil is poured into the cup, and one end of a worsted or cotton thread is dipped into the oil, and the other end passed through the tube. The capillary attraction causes the oil to ascend and pass over the orifice of the tube, whence it gradually descends, and drops slower or quicker, according to the length of the thread, or its thickness, until every particle of oil is drawn over by this capillary syphon. The tube is intended to be put into the bearings of shafts, &c., and is made of any size that may be wished. If oil, or other liquids, is desired to be dropped upon a grindstone or other surface, this cup can have a handle to it, or be hung from the ceiling.

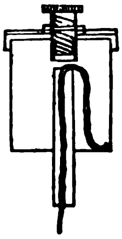
Fig. 648. It is frequently required to stop the capillary action when the machinery is not going; and this has been effected by means of a tightening screw, which passes through a screw boss in the cover of the cup, and presses against the internal orifice of the tube, preventing the oil from passing.

Fig. 649. As I find when these screw cups (*fig.* 648) are used upon beams of engines and moving bearings, that the screw is apt to be tightened by the motion; and also, as I think the action of the screw is uncertain, from the workman neglecting to screw it down sufficiently, it answers best to take out the capillary thread when the lubrication is not required; and to effect this easily, I have a tin top to the cup, with a round pipe soldered to it: this pipe has a slit in it, like a pencil case, and allows a bolt B to slide easily in it. In *fig.* 650, the bolt is down; in *fig.* 651, the bolt, which is a piece of brass wire, is drawn up, and there is no capillary action between the thread and the oil. In *fig.* 651, it will be observed, that the bolt is kept in its place by its head C, resting in a lateral slit in the pipe, and it cannot be drawn out on account of the pin E. One end of the thread is fastened to the eye-hole at the bottom of the bolt, and the other end is tied to a small wire which crosses the lower orifice of the tube at D, and which is shown in plan *fig.* 652.

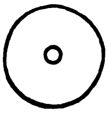
By this simple contrivance the capillary action can be stopped or renewed in a second, without removing the top of the lubricator.

The saving by this plan, instead of pouring oil into the bearings, is 2 gallons out of 3, while the bearings are better oiled.

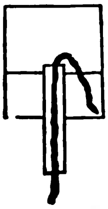
648



646



647



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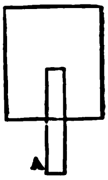
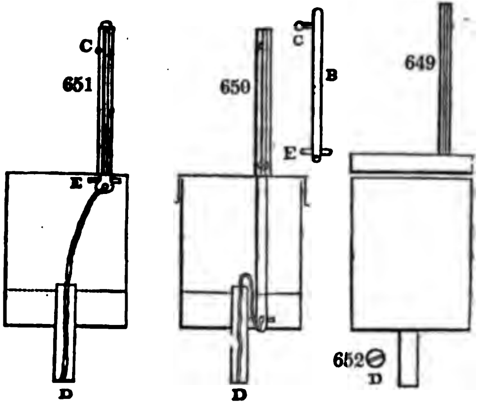




“ I send you the drawings of the lubricators, with a detailed explanation. I have omitted to state, that the saving in labor is considerable where there are many joints to keep oiled three or four times a day; and that the workman does not with this apparatus, run the risk of being caught by the machinery. Perhaps your friends may be at a loss how to tie on the cotton or worsted thread. I pass a long thread through the eye-hole E of the bolt, and then draw the two ends through the tube by a fine wire with a hook to it, one end on one side of the cross wire D, and the other end on the other side. I then put the cover on, and the bolt in the position shown in *fig*. 651; when by drawing the two ends of the thread, and tying them across the wire D, you have the exact length required. When you wish to see the quantity of oil remaining in the lubricator, the bolt must be dropped as in *fig*. 650, and you can then lift the cover a little way off, without breaking the thread, and replenish with oil. The cost of *fig*. 650, in tin plate, is 9*d*. The figures in the wood cuts are one third of the full size.

“ Believe me to be yours sincerely,
“ E. J. Woolsey.”

LUPININE, is a substance of a gummy appearance, so named by M. Cussola, because it was obtained from Lupines.

LUPULINE, from *Humulus Lupulus*; is the peculiar bitter aromatic principle of the hop. See Beer.

LUTE (from *lutum*, clay; *Lut*, Fr.; *Kitte*, *Beschläge*, Germ.) is a pasty or loamy matter employed to close the joints of chemical apparatus, or to coat their surfaces, and protect them from the direct action of flame. Lutes differ according to the nature of the vapors which they are destined to confine, and the degree of heat which they are to be exposed to.

1. *Lute of linseed meal*, made into a soft plastic dough with water, and immediately applied pretty thick to junctions of glass, or stone-ware, makes them perfectly tight, hardens speedily, resists acid and ammoniacal vapors, as also a moderate degree of heat. It becomes stronger when the meal is kneaded with milk, lime-water, or solution of glue.

2. Lute of thick gum-water, kneaded with clay, and iron filings, serves well for permanent junctions, as it becomes extremely solid.

3. By softening in water a piece of thick brown paper, kneading it first with rye-

flour paste, and then with some potter's clay, till it acquire the proper consistence, a lute is formed which does not readily crack or scale off.

4. Lute, consisting of a strong solution of glue kneaded into a dough with new slaked lime, is a powerful cement, and with the addition of white of egg, forms the *lut d'ane*;—a composition adapted to mend broken vessels of porcelain and stone-ware.

5. Skim-milk cheese, boiled for some time in water, and then triturated into paste with fresh-slaked lime, forms also a good lute.

6. Calcined gypsum, diffused through milk, solution of glue or starch, is a valuable lute, in many cases.

7. A lute made with linseed, melted caoutchouc, and pipe-clay, incorporated into a smooth dough, may be kept long soft when covered in a cellar, and serves admirably to confine acid vapors. As it does not harden, it may therefore be applied and taken off as often as we please.

8. Caoutchouc itself, after being melted in a spoon, may be advantageously used for securing joints against chlorine and acid vapors, in emergencies when nothing else would be effectual. It bears the heat at which sulphuric acid boils.

9. The best lute for joining crucibles inverted into each other, is a dough made with a mixture of fresh fire-clay, and ground fire-bricks, worked with water. That cement if made with solution of borax answers still better, upon some occasions, as it becomes a compact vitreous mass in the fire. See CEMENTS.

LUTEOLINE, is a yellow coloring matter discovered by Chevreul in weld. When sublimed, it crystallizes in needles.

LYCOPODIUM CLAVATUM. The seeds of the lycopodium ripen in September. They are employed, on account of their great combustibility, in theatres, to imitate the sudden flash of lightning, by throwing a quantity of them from a powder puff, or bellows, across the flame of a candle.

LYDIAN STONE is flint-slate.

M.

MACARONI is a dough of fine wheat flour, made into a tubular or pipe form, of the thickness of goose-quills, which was first prepared in Italy, and introduced into commerce under the name of Italian or Genoese paste. The wheat for this purpose must be ground into a coarse flour, called *gruau* or *semoule*, by the French, by means of a pair of light mill-stones, placed at a somewhat greater distance than usual. This *semoule* is the substance employed for making the dough. For the mode of manufacturing it into pipes, see VERMICELLI.

MACE is a somewhat thick, tough, unctuous membrane, reticulated or chapt, of a yellowish-brown or orange color. It forms the envelop of the shell of the fruit of the *myristica moschata*, which contains the nutmeg. It is dried in the sun, after being dipped in brine; sometimes it is sprinkled over with a little brine, before packing, to prevent the risk of moulding. Mace has a more agreeable flavor than nutmeg; with a warm and pungent taste. It contains two kinds of oil; the one of which is unctuous, bland, and of the consistence of butter; the other is volatile, aromatic, and thinner. The membrane is used as a condiment in cookery, and the aromatic oil in medicine.

MACERATION (Eng. and Fr.; *Einweichen*, Germ.), is a preparatory steep to which certain vegetable and animal substances are submitted, with the view of distending their fibres or pores, and causing them to be penetrated by such menstrua as are best adapted to extract their soluble parts. Water alone, or mixed with acids, alkalis, or salts; alcohol and ether, are the liquids usually employed for that purpose.

MACLE is the name of certain diagonal black spots in minerals, like the ace of diamonds in cards, supposed to proceed from some disturbance of the particles in the act of crystallization.

MADDER (*Garance*, Fr.; *Farberröthe*, Germ.), a substance very extensively used in dyeing, is the root of the *Rubia tinctorum*, a plant, of which two species are distinguished by Linnæus.

The best roots are those which have the size of a writing quill, or, at most, of the little finger. They are semi-transparent, and reddish; have a strong odor, and a smooth bark. They should be of two or three years' growth.

The madder, taken from the ground and picked, must be dried in order to be ground and preserved. In warm climates it is dried in the open air; but, elsewhere, stoves must be employed.

The stringy filaments and epidermis are to be removed, called *mulls*; as also the pith, so as to leave nothing but the ligneous fibres.

The preparation of madders is carried on in the department of the Rhone, in the following manner.

The roots are dried in a stove heated by means of a furnace, from which the air is allowed to issue only at intervals, at the moment when it is judged to be saturated with moisture. The furnace-flue occupies a great portion of the floor; above are three close gratings, on which the roots are distributed in layers of about two decimetres (nearly 8 inches). At the end of 24 hours, those which are on the first grated floor directly above the stove are dry, when they are taken away and replaced by those of the superior floors. This operation is repeated whenever the roots over the stove are dry. The dry roots are thrashed with a flail, passed through fanners similar to those employed for corn, and then shaken upon a very coarse sieve. What passes through is farther winnowed and sifted through a finer sieve than the first. These operations are repeated five times, proceeding successively to sieves still finer and finer, and setting aside every time what remains on the sieve. What passes through the fifth sieve is rejected as sand and dust. After these operations, the whole fibrous matters remaining on the sieve are cleaned with common fanners, and women separate all the foreign matters which had not been removed before. For dividing the roots, afterwards, into different qualities, a brass sieve is made use of, whose meshes are from six to three millimetres in diameter (from ¼th to ⅛th inch E.) What passes through the finest is rejected; and what passes through the coarsest is regarded as of the best quality. These roots, thus separated, are carried into a stove, of a construction somewhat different from the first. They are spread out in layers of about a decimetre in thickness (nearly 4 inches E.), on large lattice-work frames, and the drying is known to be complete, when on taking up a handful and squeezing it, the roots break easily. On quitting the stove, the madder is carried, still hot, into a machine, where it is minced small, and a sieve separates the portion of the bark reduced to powder. This operation is repeated three or four times, and then the bolter is had recourse to. What passes through the sieve, or the brass meshes of the bolter, is regarded as common madder; and what issues at the extremity of the bolter is called the flour. Lastly, the madder which passes through the bolter is ground in a mill with vertical stones, and then passed through sieves of different sizes. What remains above is always better than what goes through.

The madder of Alsace is reduced to a very fine powder, and its coloring matter is extracted by a much longer ebullition than is necessary for the lizari of the Levant. The prepared madders ought to be carefully preserved from humidity, because they easily imbibe moisture, in which case fermentation spoils their color.

D'Ambourney and Beckman have asserted, that it is more advantageous to employ the fresh root of madder than what has been submitted to desiccation, especially by means of stoves. But in its states of freshness, its volume becomes troublesome in the dyeing bath, and uniform observation seems to prove that it ameliorates by age. Besides, it must be rendered suceptible of keeping and carrying easily.

It appears that madder may be considered as composed of two coloring substances, one of which is dun (tawny), and the other is red. Both of these substances may combine with the stuff. It is of consequence, however, to fix only the red part. The dun portion appears to be more soluble, but its fixity on stuffs may possibly be increased by the affinity which it has for the red portion.

The different additions made to madder, and the multiplied processes to which it is sometimes exposed, have probably this separation for their chief object.

The red portion of madder is soluble, but in small quantity, in water. Hence but a limited concentration can be given to its solution. If the portion of this substance be too much increased, so far from obtaining a greater effect, we merely augment the proportion of the dun part, which is the more soluble of the two.

In consequence of the Société Industrielle of Mulhausen having offered in the year 1826 large premiums to the authors of the best analytical investigation of madder, eight memoirs were transmitted to it in the year 1827. They were examined with the greatest care by a committee consisting of able scientific and practical men. None of the competitors however fulfilled the conditions of the programme issued by the society; but four of them received a tribute of esteem and gratitude from it; MM. Robiquet and Colin at Paris, Kuhlmann at Lille, and Houton-Libillardière. Fresh premiums were offered for next year, to the amount of 2000 francs.

Every real discovery made concerning this precious root, would be of vast consequence to dyers and calico-printers. Both M. Kuhlmann, and Robiquet and Colin, conceived that they had discovered a new principle in madder, to which they gave the name *alizarine*. The latter two chemists treated the powdered madder with sulphuric acid, taking care to let it heat as little as possible. By this action the whole is carbonized, except perhaps the red matter. The charcoal thus obtained is pulverized, mixed with water, thrown upon a filter, and well washed in the cold. It is next dried, ground, and diffused through fifty parts of water, containing six parts of alum. This mixture is then boiled for one quarter of an hour, and thrown upon a filter cloth while boiling hot. The residuum is once more treated with a little warm alum water. The two liquors are to be mixed, and one part of sulphuric acid poured into them; when they are allowed to cool with occasional agitation. Flocks now make their appearance; the clear liquid is decanted, and the grounds are thrown upon a filter. The precipitate is to be washed, first with acidulated water, then with pure water, and dried, when the coloring matter is obtained in a red or purple state. This purple substance, when heated dry, gives out alizarine, and an empyreumatic oil, having an odor of animal matter; while a charcoally matter remains.

M. Dan. Kœchlin, the justly celebrated calico-printer of Mulhausen, has no faith in alizarine as the dyeing principle of madder; and thinks moreover that, were it of value, it could not be extracted on the great scale, on account of the destructive heat which would result from the acid acting upon a considerable body of the ground madder. Their alizarine is not a uniform substance, as it ought to be, if a proximate principle; for samples of it obtained in different repetitions of the process have produced very variable effects in dyeing. The madders of Avignon, though richer in color than those of Alsace, afford however little or no alizarine. In fact, *purpurine*, the crude substance from which they profess to extract alizarine, is a richer dye than this *pure* substance itself.

Madder contains so beautiful and so fast a color, that it has become of almost universal employment in dyeing; but that color is accompanied with so many other substances which mask and degrade it, that it can be brought out and fixed only after a series of operations more or less difficult and precarious. This dye is besides so little soluble, that much of it is thrown away in the dye-house; the portion supposed to be exhausted being often as rich as other fresh madder; hence it would be a most valuable improvement in this elegant art to insulate this tinctorial body, and make it a new product of manufacture.

Before the time of Haussmann, an apothecary at Colmar, the madder bath was subject to many risks, which that skilful chemist taught dyers how to guard against, by introducing a certain quantity of chalk into the bath. A change of residence led Haussman to this fortunate result. After having made very fine reds at Rouen, he encountered the greatest obstacles in dyeing the same reds at Logelbach near Colmar, where he went to live. Numerous trials, undertaken with the view of obtaining the same success in his new establishment, proved that the cause of his favorable results at Rouen existed in the water, which contained carbonate of lime in solution, whilst the water of Logelbach was nearly pure. He then tried a factitious calcareous water, by adding chalk to his dye bath. Having obtained the most satisfactory results, he was not long of producing here as beautiful and as solid reds as he had done at Rouen. This practice became soon general among the calico-printers of Alsace, though in many dye-works the chalk is now replaced by lime, potash, or soda. But when the madder of Avignon is used, all these antacid correctives become unnecessary, because it contains a sufficient quantity of carbonate of lime; an important fact first analytically demonstrated by that accurate chemist M. Henri Schlumberger of Mulhausen. Avignon madder indicates the presence of carbonate of lime in it, by effervescing with dilute acids, which Alsace madder does not.

M. Kuhlman found a free acid resembling the malic, in his analysis of madders. But his experiments were confined to those of Alsace. The madders of Avignon are on the contrary alkaline, as may be inferred from the violet tint of the froth of their infusions; whereas that of the Alsace madders is yellowish, and it strongly reddens litmus paper. This important difference between the plants of these two districts, depends entirely upon the soil; for madders grown in a calcareous shelly soil in Alsace, have been found to be possessed of the properties of the Avignon madder.

The useful action of the carbonate and the phosphate of lime in the madder of Avignon, explains why madders treated with acids which remove their calcareous salts, without taking away their coloring matter, lose the property of forming fast dyes. Many manufacturers are in the habit of mixing together, and with advantage, different sorts of madder. That of Avignon contains so much calcareous matter that, when mixed with the madder of Alsace, it can compensate for its deficiency. Some of the latter is so deficient as to afford colors nearly as fugitive as those of Brazil wood and quercitron. The Alsace madders by the addition of chalk to their baths, become as fit for dyeing Turkey reds as those of Avignon. When the water is very pure, one part of chalk ought to be used to five of Alsace madder, but when the waters are calcareous, the chalk should be omitted. Lime, the neutral phosphate of lime, the carbonate of magnesia, oxyde and carbonate of zinc, and several other substances, have the property of causing madder to form a fast dye, in like manner as the carbonate of lime.

The temperature of from 50° to 60° R. (145° to 167° F.), is the best adapted to the solution of the coloring matter, and to its combination with the mordants; and thus a boiling heat may be replaced advantageously by the long continuance of a lower temperature. A large excess of the dye-stuff in the bath is unfavorable in two points of view; it causes a waste of coloring matter, and renders the tint dull. It is injurious to allow the bath to cool, and to heat it again.

In a memoir published by the Society of Mulhausen, in September, 1835, some interesting experiments upon the growth of madders in factitious soils are related by MM. Kœchlin, Persoz, and Schlumberger. A patch of ground was prepared containing from 50 to 80 per cent. of chalky matter, and nearly one fifth of its bulk of good horse-dung. Slips of Alsace and Avignon madders were planted in March, 1834, and a part of the roots were reaped in November following. These roots, though of only six months growth, produced tolerably fast dyes, nor was any difference observable between the Alsace and the Avignon species; whilst similar slips or cuttings, planted in a natural non-calcareous soil, alongside of the others, yielded roots which gave fugitive dyes. Others were planted in the soil of Palud, transported from Avignon, which contained more than 90 per cent. of carbonate of lime, and they produced roots that gave still faster dyes than the preceding. Three years are requisite to give the full calcareous impregnation to the indigenous madders of Avignon.

As to the function of the chalk, valuable observations, made long ago by M. Daniel Kœchlin, have convinced him, that the combination of two different bases with a coloring matter, gave much more solidity to the dye, in consequence, undoubtedly, of a greater insolubility in the compound. Experiments recently made by him and his colleagues above named, prove that in all cases of madder dyeing under the influence of chalk, a certain quantity of lime becomes added to the aluminous mordant. In the subsequent clearing with a soap bath, some of the alumine is removed, and there remains upon the fibre of the cloth a combination of these two earths in atomic proportions. Thus the chalk is not for the purpose of saturating the acid, as had been supposed, but of forming a definite compound with alumina, and probably also with the fatty bodies, and the coloring matter itself.

The red mordants are prepared commonly in Alsace, as follows:—The crushed alum and acetate of lead being weighed, the former is put into a deep tub, and dissolved by adding a proper quantity of hot water, when about one tenth of its weight of soda crystals is introduced to saturate the excess of acid in the alum. The acetate of lead is now mixed in; and as this salt dissolves very quickly, the reaction takes place almost instantly. Care must be taken to stir for an hour. The vessel should not be covered, lest its contents should cool too slowly.

The different mordants most generally employed for madder, are detailed under *Colors*, in CALICO-PRINTING and MORDANT.

Much mordant should not be prepared at once, for sooner or later it will deposite some sub-acetate of alumina. This decomposition takes place even in corked vials in the cold; and the precipitate does not readily dissolve again in acetic acid. All practical men know that certain aluminous mordants are decomposed by heating them, and restored on cooling, as Gay Lussac has pointed out. He observed, that by adding to pure acetate of alumina, some alum or sulphate of potash, the mixture acquires the property of forming a precipitate with a heat approaching the boiling point, and of re-dissolving on cooling. The precipitate is alumina nearly pure, according to M. Gay Lussac; but, by M. Kœchlin's more recent researches, it is shown to be sub-sulphate of alumina, containing eight times as much base as the neutral sulphate.

Madder dye.—On account of the feeble solubility of its coloring matter in water, we cannot dye with its decoction; but we must boil the dye-stuff along with the goods to be dyed; whereby the water dissolves fresh portions of the dye, and imparts it in succession to the textile fibres. In dyeing with madder, we must endeavor to fix as little of the dun matter as possible upon the cloth.

Dyeing on wool.—Alumed wool takes, in the madder bath, a red color, which is not so bright as cochineal red, but it is faster; and as it is far cheaper, it is much used in England to dye soldiers' cloth. A mordant of alum and tartar is employed; the bath of madder, at the rate of from 8 to 16 ounces for the pound of cloth, is heated to such a degree that we can just hold our hand in it, and the goods are then dyed by the wince, without heating the bath more till the coloring matter be fixed. Vitalis prescribes as a mordant, one fourth of alum, and one sixteenth of tartar; and for dyeing, one third of madder, with the addition of a 24th of solution of tin diluted with its weight of water. He raises the temperature in the space of an hour to 200°, and afterwards he boils for 3 or 4 minutes; a circumstance which is believed to contribute to the fixation of the color. The bath, after dyeing, appears much loaded with yellow matter, because this has less affinity for the alum mordant than the red. Sometimes a little archil is added to the madder, to give the dye a pink tinge; but this is fugitive.

Silk is seldom dyed with madder, because cochineal affords brighter tints.

Dyeing on cotton and linen.—The most brilliant and fastest madder red is the Turkey or Adrianople. The common madder reds are given in the following way:—The yarn or cloth is boiled in a weak alkaline bath, washed, dried, and galled, by steeping the cotton in a decoction of bruised galls or of sumach. After drying, it is twice alumed; for which purpose, for every 4 parts of the goods, one part of alum is taken, mixed with 1-16th of its weight of chalk. The goods are dipped into a warm solution of the alum, wrung out, dried, and alumed afresh, with half the quantity. The acetate of alumina mordant, described above, answers much better than common alum for cotton. After the goods are dried and rinsed, they are passed through the dye-bath, which is formed of ¾ lb. of good madder for every pound of cotton; and it is raised to the boiling point by degrees, in the space of 50 or 60 minutes. Whenever the ebullition has continued a few minutes, the goods must be removed, washed slightly, and dyed a second time in the same way, with as much madder. They are then washed and passed through a warm soap bath, which removes the dun coloring matter.

Holterhoff prescribes for ordinary madder red the following proportions:—20 pounds of cotton yarn; 14 pounds of Dutch madder; 3 pounds of nut-galls; 5 pounds of alum; to which ½ lb. of acetate of lead has been first added, and then a quarter of a pound of chalk.

In the calico-print works the madder goods are passed through a bran bath first, immediately after dyeing; next, after several days exposure to the air, when the dun dye has become oxydized, and is more easily removed. An addition of chalk, on the principles explained above, is sometimes useful in the madder bath. If bran be added to the madder bath, the color becomes much lighter, and of an agreeable shade. Sometimes bran-water is added to the madder bath, instead of bran.

Adrianople or Turkey red.—This is the most complicated and tedious operation in the art of dyeing; but it produces the fastest color which is known. This dye was discovered in India, and remained long a process peculiar to that country. It was afterwards practised in other parts of Asia and in Greece. In 1747, Ferquet and Goudard brought Greek dyers into France, and mounted near Rouen, and in Languedoc, Turkey-red dye works. In 1765, the French government, convinced of the importance of this business, caused the processes to be published. In 1808, Reber, at Mariakirch, furnished the finest yarn of this dye, and M. Kochlin became celebrated for his Turkey-red cloth.

Process for Turkey-red.—The first step consists in clearing the yarn or cloth in alkaline baths, and dipping them in oily liquors, to which sheep's dung was formerly added. This operation is repeated several times, the goods being dried after each immersion. There next follows the cleansing with alkaline liquors to remove the excess of oil, the galling, the aluming, the maddering, the brightening or removing the dun part of the dye by boiling, at a high temperature, with alkaline liquid, and the rosing by boiling in a bath of salt of tin. We shall give some details concerning this tedious manipulation, and the differences which exist in it in the principal dye-works.

At Rouen, where the process was first brought to perfection, two methods are pursued, called the gray and the yellow course or march. In the gray, the dye is given immediately after the cotton has received the oily mordant, the gall, and the alum, as it has then a gray color. In the yellow course, it is passed through fresh oils, alum, and galls before the maddering, the cotton having then a yellow tint.

Different views have been taken of the principles of the Turkey-red dye, and the object and utility of the various steps. The most ancient notion is that of animalizing the cotton by dung and blood, but experience has proved that without any animal matter the finest color may be obtained. According to Dingler, the cotton is imbued with oil by steeping it in combinations of oil and soda; the oil is altered by repeated dryings at a high temperature; it attracts oxygen from the air, and thereby combines intimately with the cotton fibre, so as to increase the weight of the stuff. The dung, by a kind of fermentation, accelerates the oxydizement, and hence crude oil is preferable to pure. In England, the mucilaginous oils of Gallipoli are preferred, and in Malabar, oils more or less rancid. The drying oils do not answer. The subsequent treatment with the alkaline liquors removes the excess of oil, which has not been oxydized and combined; a hard drying completely changes that which remains in the fibres; the aluming which follows combines alumina with the cotton; the galling tans the fibres, producing a triple compound of oil and alum, which fixes the coloring matter. The object of the other steps is obvious.

According to Wuttich, the treatment with oil opens the cotton so as to admit the mordant and the coloring matter, but the oil and soap do not combine with the fibres. In the alkaline baths which follow, the oil is transformed into soap and removed; whence the cotton should not increase in weight in the galling and aluming; the cotton suffers a kind of tanning, and the saline parts of the blood assist in fixing the madder dye.

The German process improved, according to Dingler, consists of the following operations: mordant of an oily soap or a soapy liniment, hard drying; alkaline bath, drying, steeping, rinsing away of the uncombined mordant, drying; galling, drying; aluming, drying, steeping in water containing chalk, rinsing; maddering, airing, rinsing; brightening with an alkaline boil, and afterwards in a bath containing salt of tin; then washing and drying.

The yarn or the cloth must be first well worked in a bath of sheep's dung and oil, compounded as follows:—25 pounds of sheep's dung are to be bruised in a solution of pure caustic potash of hydrometer strength 3°, and the mixed liquor is to be passed through a sieve. Two pounds of fine oil are now to be poured into 16 pounds of his ley, after which 30 pounds of coarse oil are to be added, with agitation for ¼ of an hour. Other 4 pounds of hot ley are to be well stirred in, till the whole is homogeneous. This proportion of mordant is sufficient for 100 pounds of cotton yarn, for 90 pounds of unbleached or 100 pounds of bleached cotton goods. The cotton stuff, after being well wrung out, is to be laid in a chest and covered with a lid loaded with weights, in which state it should remain for five days. At the end of 24 hours, the cotton becomes hot with fermentation, gets imbued with the mordant, and the oil becomes rapidly altered. The goods are next exposed freely to the air during the day, and in the evening they are dried in a hot chamber, exposed to a temperature of 158° F., for 6 or 8 hours, which promotes the oxydizement of the oil.

The goods are now passed the second time through a soapy-oil mordant similar to the first, then dried in the air by day, and in the hot stove by night. The third and fourth oil-soap steeps are given in the same way, but without the dung. The fifth steep is composed of a ley at 2°, after which the goods must also be dried. Indeed, from the first to the fourth steep, the cotton stuff should be put each time into a chamber heated to 145° F. for 12 or 15 hours, and during 18 hours after the fifth steep.

The uncombined oil must, in the next place, be withdrawn by the *degraissage*, which consists in steeping the goods for 6 hours in a very weak alkaline ley. After rinsing and wringing, they are dried in the air, and then put into the hot stove.

The goods are now galled in a bath formed of 36 pounds of Sicilian sumach, boiled for 3 hours in 260 pounds of water, and filtered. The residuum is treated with 190 fresh pounds of water. This decoction is heated with 12 pounds of pounded nut-galls to the boiling point, allowed to cool during the night, and used next morning as hot as the hand can bear; the goods being well worked through it. They are again dried in the air, and afterwards placed in a stove moderately heated. They are next passed through a tepid alum bath, containing a little chalk; left afterwards in a heap during the night, dried in the air, and next in the stove. The dry goods are finally passed through hot water containing a little chalk, wrung out, rinsed, and then maddered.

For dyeing, the copper is filled with water, the fire is kindled, and an ounce and a half of chalk is added for every pound of madder; a pound and a quarter of madder being taken for every pound of cotton yarn. The goods are now passed through the bath, so that they penetrate to near its bottom. The fire must be so regulated, that the copper will begin to boil in the course of from 2½ to 3 hours; and the ebullition must be continued for an hour; after which the yarn is aired and rinsed. Cloth should be put into the dye-bath when its temperature is 77° and winced at a heat of from 100° to 122° during the first hour; at 167° during the second; and at the boiling point when the third hour begins. It is to be kept boiling for half an hour; so that the maddering lasts four hours. Dingler does not add sumach or galls to the madder bath, because their effect is destroyed in the subsequent brightening, and he has no faith in the utility of blood.

After being dyed, the goods are washed, pressed, and subjected to a soapy alkaline bath at a high heat, in a close boiler, by which the dun parts of the galls and the madder are dissolved away, and the red color remains in all its lustre. This operation is called brightening. It is repeated in a similar liquor, to which some muriate of tin is added for the purpose of enlivening the color and giving it a rosy tint. Last of all, the goods are rinsed, and dried in the shade.

The *Elberfeld* process consists for 100 lbs. of the following steps:—

1. Cleaning the cotton by boiling it for four hours in a weak alkaline bath, cooling and rinsing.

2. Working it thoroughly four times over in a steep, consisting of 300 pounds of water, 15 pounds of potash, 1 pailful of sheep's dung, and 12½ pounds of olive oil, in which it should remain during the night. Next day it is drained for an hour, wrung out and dried. This treatment with the dung steep, and drying, is repeated 3 times.

3. It is now worked in a bath containing 120 quarts of water, 18 pounds of potash,

and 6 quarts of olive oil; then wrung out and dried. This steep is also repeated 4 times.

4. Steeping for a night in the river is the next process; a slight rinsing without wringing, and drying in the air.

5. Bath made of a warm decoction (100° F.) of sumach and nut-galls, in which the goods remain during the night; they are then strongly wrung, and dried in the air.

6. Aluming with addition of potash and chalk; wringing; working it well through this bath, where it is left during the night.

7. Draining, and strong rinsing the following day; piling up in a water cistern.

8. Rinsing repeated next day, and steeping in water to remove any excess of alum from the fibres; the goods continue in the water till they are taken to the dyeing-bath.

9. The maddering is made with the addition of blood, sumach, and nut-galls; the bath is brought to the boil in 1 hour and ¾, and kept boiling for half an hour.

10. The yarn is rinsed, dried, boiled from 24 to 36 hours in a covered copper, with an oily alkaline liquid; then rinsed twice, laid for two days in clear water, and dried.

11. Finally, the greatest brightness is obtained by boiling for three or four hours in a soap bath, containing muriate of tin; after which the yarn is rinsed twice over, steeped in water, and dried.

Process of Haussmann.—He treats cotton twice or 4 times in a solution of aluminated potash, mixed with one thirty-eighth part of linseed oil. The solution is made by adding caustic potash to alum. He dries and rinses each time, and dries after the last operation. He then rinses and proceeds to the madder bath. For the rose color, he takes one pound of madder for one pound of cotton; for carmine red, he takes from 2 to 3 pounds; and for the deepest red, no less than 4 pounds. It is said that the color thus obtained surpasses Turkey red.

The French process, by Vitalis of Rouen.—First operation. Scouring with a soda ley, of 1° Baumé, to which there is usually added the remainder of the *white* preparation bath, which consists of oil and soda with water. It is then washed, wrung out, and dried.

In the second operation, he states that from 25 to 30 pounds of sheep's dung are commonly used for 100 pounds of cotton yarn. The dung is first steeped for some days in a ley of soda, of 8° to 10° B. This is afterwards diluted with about 500 pints of a weaker ley, and at the same time bruised with the hand in a copper basin whose bottom is pierced with small holes. The liquor is then poured into a vat containing 5 or 6 pounds of fat oil (Gallipoli), and the whole are well mixed. The cotton is washed in this, and the hanks of yarn are then stretched on perches in the open air, and turned from time to time, so as to make it dry equably. After receiving thus a certain degree of desiccation, it is carried into the drying house, which is heated to 50° Reaumur (144° Fahrenheit), where it loses the remainder of its moisture, which would have prevented it from combining with the other mordants which it is afterwards to receive. What is left of the bath is called *avances*, and is added to the following bath. Two, or even three dung baths are given to the cotton, when it is wished to have very rich colors. When the cotton has received the dung baths, care must be taken not to leave it lying in heaps for any length of time, lest it should take fire; an accident which has occasionally happened.

The white bath is prepared by pouring 6 pounds of fat oil into 50 pints of soda water, at 1° or sometimes less, according as, by a preliminary trial, the oil requires. This bath ought to be repeated two, three, or even a greater number of times, as more or less body is to be given to the color.

To what remains of the white bath, and which is also styled *avances*, about 100 pints of soda ley of two or three degrees are added. Through this the cotton is passed as usual. Formerly it was the practice to give two, or three, or even four oils. Now, two are found to be sufficient.

The cotton is steeped for five or six hours in a tepid solution of soda, of 1° at most; it is set to drain, is then sprinkled with water, and at the end of an hour is washed, hank by hank, to purge it entirely from the oil. What remains of the water of degraissage, serves for the scouring or first operation.

For 100 pounds of cotton, from 20 to 25 pounds of galls in sorts must be taken, which are bruised and boiled in about 100 pints of water, till they crumble easily between the fingers. The galling may be done at two operations, dividing the above quantity of galls between them, which is thought to give a richer and more uniform color.

The aluming of 100 pounds of cotton requires from twenty-five to thirty pounds of pure alum, that is, alum entirely free from ferruginous salts. The alum should be dissolved without boiling, in about 100 pints of river or rain water. When the alum is dissolved, there is to be poured in a solution of soda, made with the sixteenth part of the weight of the alum. A second portion of the alkaline solution must not be poured in till the effervescence caused by the first portion has entirely ceased—and so in succession. The bath of saturated alum being merely tepid, the cotton is passed through it, as in the gall bath, so as to impregnate it well, and it is dried with the precautions recommended above. The dyers who gall at two times, alum also twice, for like reasons.

For 25 pounds of cotton, 25 pints of blood are prescribed, and 400 pints of water. Whenever the bath begins to warm, 50 pounds of madder are diffused through the bath; though sometimes the maddering is given at two operations, by dividing the madder into two portions.

The brightening bath is prepared always for 100 pounds of cotton, with from four to five pounds of rich oil, six pounds of Marseilles white soap, and 600 litres of soda water of 2° B.

The rosing is given with solution of tin, mixed with soap water.

The Turkey-red dye of Messrs. Monteith and Co., of Glasgow, is celebrated all over the world, and merits a brief description here.

The calico is taken as it comes from the loom without bleaching, for the natural color of the cotton wool harmonizes well with the dye about to be given; it is subjected to a fermentative steep for 24 hours, like that preliminary to bleaching, after which it is washed at the dash wheel. It is then boiled in a ley, containing about 1 pound of soda crystals for 12 pounds of cloth. The oiling process now begins. A bath is made with 10 gallons of Gallipoli oil, 15 gallon measures of sheep's dung not indurated; 40 gallons of solution of soda crystals, of 1·06 specific gravity; 10 gallons of solution of pearl-ash of spec. grav. 1·04; and 140 gallons of water; constituting a milk-white, soapy solution of about spec. grav. 1·022. This liquor is put into a large cylindrical vat, and constantly agitated by the rotation of wooden vanes, which are best constructed on the plan of the mashing apparatus of a brewery, but far slighter. This saponaceous compound is let off as wanted by a stopcock into the trough of a padding machine, in order to imbue every fibre of the cloth in its passage. This impregnation is still more fully ensured by laying the padded cloth aside in wooden troughs during 16 or 18 days. The sheep's dung has been of late years disused by many Turkey-red dyers, both in England and France, but it is found to be advantageous in producing the very superior color of the Glasgow establishment. It is supposed, also, to promote the subsequent bleaching during the exposure on the green; which is the next process in favorable weather, but in bad weather the goods are dried over a hot-flue.

The cloth is padded again with the saponaceous liquor; and again spread on the grass, or dried hard in the stove. This alternation is repeated a third time, and occasionally, even a fourth.

The cloth by this time is varnished as it were with oil, and must be cleansed in a certain degree by being passed through a weak solution of pearl-ash, at the temperature of about 122° F. It is then squeezed by the rollers and dried.

A second system of oiling now commences, with the following liquor:—10 gallons of Gallipoli oil; 30 gallons of soda crystals ley, of spec. grav. 1·06; and 10 gallons of caustic potash ley, of specific gravity 1·04, thoroughly diffused through 170 gallons of water. With this saponaceous liquor the cloth is padded as before, and then passed between squeezing-rollers, which return the superfluous liquor into the padding-trough. The cloth may be now laid on the grass if convenient; but at any rate it must be hard dried in the stove.

These saponifying, grassing, and drying processes, are repeated three times; whereby the cloth becomes once more very oleaginous, and must be cleansed again by steeping in a compound ley of soda crystals and pearl-ash of the spec. grav. 1·012, at the temperature of 122°. The cloth is taken out, squeezed between rollers to save the liquor, and washed. A considerable portion of the mingled alkalis disappear in this operation, as if they entered into combination with the oil in the interior of the cotton filaments. The cloth is now hard dried.

Galling is the next great step in the Turkey-red preparation; and for its success all the oil should have been perfectly saponified.

From 18 to 20 pounds of Aleppo galls (for each 100 lbs. of cloth) are to be bruised and boiled for 3 or 4 hours, in 25 gallons of water, till 5 gallons be evaporated; and the decoction is to be then passed through a searce. Two pounds of sumach may be substituted for every pound of galls. The goods must be well padded with this decoction, kept at 90° F., passed through squeezing-rollers, and dried. They are then passed through a solution of alum of the spec. grav. 1·04, to which a certain portion of chalk is added to saturate the acid excess of that supersalt; and in this cretaceous mixture, heated to 110°, the cloth is winced and steeped for 12 hours. It is then passed between squeezing-rollers, and dried in the stove.

The *maddering* comes next.

From two to three pounds of madder, ground to powder in a proper mill, are taken for every pound of cloth. The cloth, as usual in maddering, is entered into the cold bath, and winced by the automatic reel during one hour that the bath takes to boil, and during an ebullition of two hours afterwards. One gallon of bullock's blood is added to the cold bath for every 25 pounds of cloth; being the quantity operated upon in one bath. The utility of the blood in improving the color has been ascribed to its coloring particles; but it is more probably owing to its albuminous matter combining with the margarates of soda and potash condensed in the fibres.

As madder contains a dingy brown coloring matter associated with the fine red, the goods must be subjected to a clearing process to remove the former tinge, which is more fugitive than the latter. Every hundred pounds of cloth are therefore boiled during 12 hours at least, with water containing 5 pounds of soda crystals, 8 pounds of soap, and 16 gallons of the residual pearl-ash and soda ley of the last cleansing operation. By this powerful means the dun matter is well nigh removed; but it is completely so by a second boil, at a heat of 250° F., in a tight globular copper, along with 5 pounds of soap, and 1 pound of muriate of tin crystals, dissolved in a sufficient body of water for 100 pounds of cloth. The muriate of tin serves to raise the madder red to a scarlet hue. A margarate of tin is probably fixed upon the cloth in this operation.

When the weather permits, the goods should be now laid out for a few days on the grass. Some manufacturers give them a final brightening with a weak bath of a chloride of lime; but it is apt to impoverish the color.

According to the latest improvements of the French dyers, each of the four processes of oiling, mordanting, dyeing, and brightening differs, in some respects, from the above.

1. Their first step is boiling the cloth for four hours, in water containing one pound of soap for every four pieces. Their saponaceous bath of a creamy aspect is used at a temperature of 75° F.; and it is applied by the padding machine 6 times, with the grassing and drying alternations. In winter, when the goods cannot be exposed on the grass, no less than 12 alternations of the saponaceous or white bath are employed, and 8 in spring. They consider the action of the sun-beams to aid greatly in brightening this dye; but at midsummer, if it be continued more than 4 hours, the scarlet color produced begins to be impaired.

They conceive that the oiling operation impregnates the fibres with super-margarate of potash or soda, insoluble salts which attract and condense the alumina, and the red coloring particles of the madder, so firmly that they can resist the clearing boil.

2. Their second step, the mordanting, consists first in padding the pieces through a decoction of galls mixed with a solution of an equal weight of alum; and after drying in the hot-flue, &c., again padding them in a solution of an acetate of alumina, made by decomposing a solution of 16 lbs. of alum with 16 lbs. of acetate of lead, for 6 pieces of cloth, each 32 *aunes* long.

3. The maddering is given at two successive operations; with 4 pounds of Avignon madder per piece at each time.

4. The *brightening* is performed by a 12 hours' boil in water with soda crystals, soap, and salt of tin; and the *rosing* by a 10 hours' boil with soap and salt of tin. Occasionally, the goods are passed through a weak solution of chloride of potash. When the red has too much of a crimson cast, the pieces are exposed for two days on the grass, which gives them a bright scarlet tint.

Process of M. Werdet to dye broadcloth and wool by madder:—

"Preparation for 24 pounds of scoured wool:

"Take 4½ pounds of cream of tartar, 4½ pounds of pure alum; boil the wool gently for 2 hours, transfer it into a cool place, and wash it next day in clear water.

"*Dyeing.*—12 pounds of Avignon madder, infused half an hour at 30° R. (100° F.) Put into the bath 1 pound of muriate of tin, let the color rose for three quarters of an hour at the same heat, and drain or squeeze the madder through canvass. The whole of the red dye will remain upon the filter, but the water which has passed through will be as deep a yellow as a weld bath. The boiler with the dye must now be filled up with clear river water, and heated to 100° F. Two ounces of the solution of the tartar and alum must be poured into it, and the wool must be turned over in it for an hour and a half, while the heat is gradually raised to the boiling point. The wool is then removed and washed. It must be rosed the following day.

"*Rosing.*—Dissolve in hot water 1 pound of white Marseilles soap; let the bath cool, and pass the wool through it till it has acquired the desired shade; 15 or 20 minutes are sufficient. On coming out of this bath it should be washed.

"*Solution of deuto-muriate of tin*:—

"2 ounces of pure muriatic acid; 4 drachms of pure nitric acid; 1 ounce of distilled water. Dissolve in it, by small portions at a time, 2 drachms of grain tin, in a large bottle of white glass, shutting it after putting in the tin. This solution may be preserved for years, without losing its virtue."

I have inserted this process, as recently recommended by the French minister of commerce, and published by M. Pouillet in vol. i. of his Portefeuille Industriel, to show what *official* importance is sometimes given by our neighbors to the most frivolous things.

Madders imported for home consumption.		Gross amount of Duty paid in	
1836.	1837.	1836.	1837.
Cwts. 106,172	cwts. 79,228	£10,810	£8.081

MADREPORES are calcareous incrustations produced by *polypi* contained in cells of greater or less depth, placed at the surface of calcareous ramifications, which are fixed at their base, and perforated with a great many pores. The mode of the increase, reproduction, and death of these animals is still unknown to naturalists. Living madrepores are now-a-days to be observed only in the South American, the Indian, and the Red seas; but although their polypi are not found in our climate at present, there can be no doubt of their having existed in these northern latitudes in former times, since fossil madrepores occur in both the older and newer secondary strata of Europe.

MAGISTERY is an old chemical term to designate white pulverulent substances, spontaneously precipitated in making certain metallic solutions; as magistery of bismuth.

MAGISTRAL, in the language of the Spanish smelters of Mexico and South America, is the roasted and pulverized copper pyrites, which is added to the ground ores of silver in their *patio*, or amalgamation magma, for the purpose of decomposing the horn silver present. See SILVER, for an account of this curious process of reduction.

MAGMA is the generic name of any crude mixture of mineral or organic matters, in a thin pasty state.

MAGNANIER is the name given in the southern departments of France to the proprietor of a nursery in which silk-worms are reared upon the great scale, or to the manager of the establishment. The word is derived from *magnans*, which signifies silk-worms in the language of the country people. See SILK.

MAGNESIA (Eng. and Fr.; *Bittererde*, *Talkerde*, Germ.) is one of the primitive earths, first proved by Sir H. Davy to be the oxyde of a metal, which he called *magnesium*. It is a fine, light, white powder, without taste or smell, which requires 5150 parts of cold water and no less than 36,000 parts of boiling water for its solution. Its specific gravity is 2·3. It is fusible only by the heat of the hydroxygen blowpipe. A natural hydrate is said to exist which contains 30 per cent. of water. Magnesia changes the purple infusion of red cabbage to a bright green. It attracts carbonic acid from the air, but much more slowly than quicklime. It consists of 61·21 parts of metallic basis, and 38·79 of oxygen; and has, therefore, 20 for its prime equivalent upon the hydrogen scale. Its only employment in the arts is for the purification of fine oil, in the preparation of varnish.

Magnesia may be obtained by precipitation with potash or soda, from its sulphate, commonly called Epsom salt; but it is usually procured by calcining the artificial or natural carbonate. The former is, properly speaking, a subcarbonate, consisting of 44·69 magnesia, 35·86 carbonic acid, and 19·45 water. It is prepared by adding to the solution of the sulphate, or the muriate (the *bittern* of sea-salt evaporation works), a solution of carbonate of soda, or of carbonate of ammonia distilled from bones in iron cylinders. The sulphate of magnesia is generally made by acting upon magnesian limestone with somewhat dilute sulphuric acid. The sulphate of lime precipitates, while the sulphate of magnesia remains in solution, and may be made to crystallize in quadrangular prisms, by suitable evaporation and slow cooling. Where muriatic acid may be had in profusion for the trouble of collecting it, as in the soda works in which sea salt is decomposed by sulphuric acid, the magnesian limestone should be first acted upon with as much of the former acid as will dissolve out the lime, and then, the residuum being treated with the latter acid, will afford a sulphate at the cheapest possible rate; from which magnesia and all its other preparations may be readily made. Or, if the equivalent quantity of calcined magnesian limestone be boiled for some time in bittern, the lime of the former will displace the magnesia from the muriatic acid of the latter. This is the most economical process for manufacturing magnesia. The subcarbonate, or *magnesia alba* of the apothecary, has been proposed by Mr. E. Davy to be added by the baker to damaged flour, to counteract its acescency.

MAGNESIAN LIMESTONE (*Dolomie*, Fr.; *Bittertalk*, *Talkspath*, Germ.) is a mineral which crystallizes in the rhombohedral system. Spec. grav. 2·86; scratches calcspar; does not fall spontaneously into powder, when calcined, as common limestone does. It consists of 1 prime equivalent of carbonate of lime = 50, associated with 1 of carbonate of magnesia = 42.

Massive magnesian limestone, is yellowish-brown, cream yellow, and yellowish-gray; brittle. It dissolves slowly and with feeble effervescence in dilute muriatic acid; whence it is called *Calcaire lent dolomie* by the French mineralogists. Specific gravity 2·6 to 2·7.

Near Sunderland, it is found in flexible slabs. The principal range of hills composing this geological formation in England extends from Sunderland on the northeast coast to Nottingham, and its beds are described as being about 300 feet thick on the east of the coal field in Derbyshire, which is near its southern extremity. On the western side of the Cumberland mountains magnesian limestone overlies the coal measures near Whitehaven. The stratification of this rock is very distinct, the individual courses of stone not exceeding in general the thickness of a common brick.

The lime resulting from the calcination of magnesian limestone appears to have an injurious action on vegetation, unless applied in quantities considerably less than common lime, when it is found to fertilize the soil. After two years, its hurtful influence on the ground seems to become exhausted, even when used in undue quantity. Great quantities of it are annually brought from Sunderland to Scotland by the Fifeshire farmers, and employed beneficially by them as a manure, in preference to other kinds of lime. It has been unfairly denounced, by Mr. Tennent and Sir H. Davy, as a sterilizer.

This rock is used in many places for building; indeed, our most splendid monument of Gothic architecture, York Minster, is constructed of magnesian limestone.

MAGNESIA, NATIVE (*Brucite; Guhr-magnesien*, Fr.; *Wassertalk*, Germ.), is a white, lamellar, pearly-looking mineral, soft to the touch. Spec. grav. 2·336; tender; scratched by calc-spar; affording water by calcination; leaving a white substance which browns turmeric paper; and, by calcination with nitrate of cobalt, becoming of a lilach hue. It consists of 69·75 magnesia, and 30·25 water. It occurs in veins in the serpentine at Hoboken, in New Jersey, as also at Swinaness, in the island of Unst, Shetland.

MAGNESITE, *Giobertite;* native carbonate of magnesia occurs in white, hard, stony masses, in the presidency of Madras, and in a few other localities. It dissolves very slowly in muriatic acid, and gives out carbonic acid in the proportion of 22 parts by weight to 42 of the mineral, according to my experiments, and is therefore an atomic carbonate. It forms an excellent and beautiful mortar cement for terraces; a purpose to which it has been beneficially applied in India by Dr. Macleod.

MAGNET, NATIVE, is a mineral consisting of the protoxyde and peroxyde of iron combined in equivalent proportions. See Iron.

MAHALEB. The fruit of this shrub affords a violet dye, as well as a fermented liquor like *Kirschwasser*. It is a species of cherry cultivated in our gardens.

MALACHITE, or *mountain green*, is native carbonate of copper of a beautiful green color, with variegated radiations and zones; spec. grav. 3·5; it scratches calc-spar, but not fluor; by calcination it affords water and turns black. Its solution in the acids deposites copper upon a plate of iron plunged into it. It consists of carbonic acid 18·5; deutoxyde of copper 72·2; water 9·3.

MALATES are saline compounds of the bases, with

MALIC ACID. (*Acide malique*, Fr.; *Aepfelsaure*, Germ.) This acid exists in the juices of many fruits and plants, alone, or associated with the citric, tartaric, and oxalic acids; and occasionally combined with potash or lime. Unripe apples, sloes, barberries, the berries of the mountain ash, elder berries, currants, gooseberries, strawberries, raspberries, bilberries, brambleberries, whortleberries, cherries, ananas, afford malic acid; the house-leek and purslane contain the malate of lime.

The acid may be obtained most conveniently from the juice of the berries of the mountain ash, or barberries. This must be clarified, by mixing with white of egg, and heating the mixture to ebullition; then filtering, digesting the clear liquor with carbonate of lead, till it becomes neutral; and evaporating the saline solution, till crystals of malate of lead be obtained. These are to be washed with cold water, and purified by re-crystallization. On dissolving the white salt in water, and passing a stream of sulphureted hydrogen through the solution, the lead will be all separated in the form of a sulphuret, and the liquor, after filtration and evaporation, will yield yellow granular crystals, or cauliflower concretions, of malic acid, which may be blanched by re-dissolution and digestion with bone-black, and re-crystallization.

Malic acid has no smell, but a very sour taste, deliquesces by absorption of moisture from the air, is soluble in alcohol, fuses at 150° Fahr., is decomposed at a heat of 348°, and affords by distillation a peculiar acid, the pyromalic. It consists in 100 parts, of 41·47 carbon; 3·51 hydrogen; and 55·02 oxygen; having nearly the same composition as citric acid. A crude malic acid might be economically extracted from the fruit of the mountain ash, applicable to many purposes; but it has not hitherto been manufactured upon the great scale.

MALLEABILITY is the property belonging to certain metals, of being extended under the hammer. A table of malleability is given in the article Ductility.

585853

MALT (Eng. and Fr.; *Malz*, Germ.) is barley-corn, which has been subjected to an artificial process of germination. See BEER.

Table of the Quantity of Malt consumed by the undermentioned Brewers of London and Vicinity, from October 10, 1836, to October 10, 1837.

Brewers.	Qrs.	Brewers.	Qrs.
Barclay and Co.	100005	Jones	956
Hanbury and Co.	82798	Ufford and Oldershaw	953
Whitbread and Co.	47012	Blogg, B.	943
Reid and Co.	13945	Ing	900
Combe and Co.	40366	Keep	886
Hoare and Co.	32347	Soulby	861
Calvert and Co.	32335	Clarke, R.	834
Meux and Co.	30575	Jenner	833
Elliot and Co.	24154	Manvell	824
Taylor and Co.	23556	M'Leods	820
Charrington and Co.	18842	Braithwaite	799
Thorne and Son	16404	Addison	768
Gardner	15256	Turner	766
Ramsbottom and Co.	15227	Holt	756
J. & C. Goding (11 months)	14023	Church	742
Bricheno	9863	Clarke, S.	741
Courage and Co.	9284	Mann, Joel	733
Wood and Co.	7834	Turner	712
Goding, Thos.	7095	Mantell	693
Hazard	6674	Lock	651
Mann, Jas.	6588	Hood	649
Harris, Thos.	6042	Pink, A.	636
More	6025	Collins	598
M'Leod, B.	4960	Wright	588
Farren and Till	4783	West	565
Manners and Co.	4552	Abbott	560
Hale, George	4547	Hett (6 months)	552
Halford and Topham	3786	Wells	520
Stains and Fox	5783	Higgs	475
Lamont and Co.	3600	Harris, Robt.	470
Laxton	3583	Woodward	462
Richmond	3174	Wicks	441
Maynard	3133	Bell	440
M'Leod and Thompson	2834	Thompson	406
Tubb	2826	Mattam	400
Johnson and Wyatt	2809	M'Intosh	397
Duggan and Co.	2665	Thurlby	392
Hodgson	2400	Griffiths	391
Sherborn and Co.	2347	Kay	360
Griffith	2221	Tidman	332
Cox, John	2151	Lindsay	326
Masterman	1914	Cooper	315
Hill and Rice	1853	West	306
Gray and Dacre	1760	Carpenter	299
Plimmer	1747	Green	292
Hayward	1737	Chapman	286
Verey, W. and C.	1573	Brace	266
Williamson and Co.	1566	Clark	248
Honeyball	1512	Allen	245
Satchell and Son	1441	Powditch	238
Clarke, C.	1330	Garnett	232
Colyer	1299	Hill	222
Filmer and Wall	1298	Olley	214
Nicholls and Co.	1240	Ward	206
Hagan	1143	Bye	201
Hume	1126	Newton	175
Buckley and Co.	1025	Chadwick	169
Verey, J.	1017	Prosser	166
Collins, J.	966	Smith	164

Table of the Consumption of Malt.—*Continued.*

Brewers.	Qrs.	Brewers.	Qrs.
Edwards - - -	156	Whittaker - - -	75
Pugh - - - -	155	Begbie - - -	75
Hainstock - - -	155	Carter - - -	75
Lloyd - - - -	154	Priddle - - -	74
Reynolds - - -	151	Coomber - - -	73
Latham - - -	142	Stallwood - - -	71
Meaton - - -	140	Jones - - -	71
Brewer - - -	135	Rose - - -	67
Stirling - - -	133	Norris - - -	67
Ambler - - -	130	Remnant - - -	62
Potter - - - -	122	Kearney - - -	62
Champion - - -	121	Smith - - -	62
Miller - - - -	115	Woodroffe - - -	60
Edwards - - -	108	Knight - - -	60
Easton - - -	105	Graves - - -	54
Griffiths - - -	105	Sheppard - - -	52
Hopkins - - -	91	Field - - -	51
Hudson - - -	90	Bradfield - - -	51
Thorpe - - -	89	Webb - - - -	50
Burt - - -	88	Chapman - - -	48
Bowden - - -	88	Price - - -	45
Batt - - - -	84	Godfrey - - -	45
Phillips - - -	83	Hobbs - - -	32
Jewit - - - -	82	Denman - - -	31
Tyler - - - -	76		

		Qrs.
Quantity used - -	1836,	754,313
Quantity used - -	1837,	714,488
Decrease - -	1837,	39,825

JOHN SLATER, *Cask Inspector.*

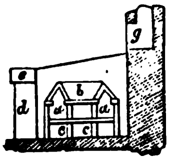
Hop-Duty, 1837 (*Old*) - - £178,578. 3*s*. 0½*d*.

Table of the Quantity of Malt from Barley, which paid Duty in

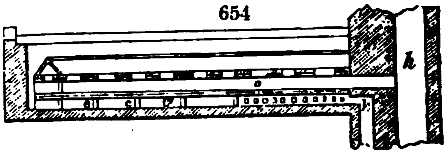
Years.	England.	Scotland.	Ireland.
	Bushels.	*Bushels.*	*Bushels.*
1834.	34,949,646	3,580,758	1,776,883
1835.	36,078,855	3,604,816	1,825,300
1836.	37,196,998	4,168,854	1,872,104
	Amount of Duties paid:		
	£	£	£
1834.	4,449,745	462,514	229,514
1835.	4,660,185	465,622	235,767
1836.	4,804,612	538,477	241,813

MALT KILN (*Darre*, Germ.) The improved malt kiln of Pistorius is represented, *fig*. 653, in a top view; *fig*. 654, in a longitudinal view and section; and *fig*. 655, in transverse section. *a a* are two quadrangular smoke flues, constructed of fire-tiles, or fire-stones, and covered with iron plates, over which a pent-house roof is laid; the whole bound by the cross-pieces *b* (*figs*. 654, 655.) These flues are built above a grating *c c*, which commences at *c′*; in front of *c′* there is a bridge of bricks. Instead of such a brick flue covered with plates, iron pipes may be used, covered with semi-cylindrical tiles, to prevent the malt that may happen to fall from being burned. *d d* are the breast walls of the kiln, 3 feet high, furnished with two apertures shut with iron doors, through which the malt that drops down may be removed from time to time. *e* is a beam of wood lying on the breast wall, against which the hurdles are laid down slantingly towards the back wall of the kiln; *f f* are two vertical flues left in the substance of the walls, through which the hot air, discharged by open pipes laid in a subjacent furnace, rises into the space between the pent-house roof and the iron plates, and is thence allowed to issue through apertures in the sides. *g* is the discharge flue in the back wall of the kiln for the air now saturated with moisture; *h* is the smoke-pipe, from which the smoke passes into the anterior flue *a*, provided with a slide-plate, for modifying the draught; the smoke thence flows off through a flue fitted also with a damper-plate into the chimney *i*. *k* is the smoke-pipe of a subsidiary fire, in case no smoke should pass through *h*. The iron pipes are 11 inches in diameter, the air-flues *f*, 5 inches, and the smoke-pipe *h*, 10 inches square; the brick flues 10 inches wide, and the usual height of bricks.

655



654



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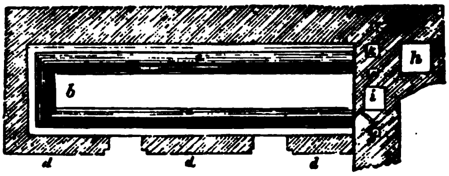

MALTHA; *Bitume Glutineux*, or mineral pitch. It is a soft glutinous substance, with the smell of pitch. It dissolves in alcohol, but leaves a bituminous residuum; as also in naptha, and oil of turpentine. It seems to be inspissated petroleum.

MANGANESE (Eng. and Fr.; *Mangan*, *Braunsteinmetal*, Germ.) is a grayish-white metal, of a fine-grained fracture, very hard, very brittle, with considerable lustre, of spec. grav. 8·013, and requiring for fusion the extreme heat of 160° Wedgewood. It should be kept in closely stoppered bottles, under naptha, like potassium, because with contact of air it speedily gets oxydized, and falls into powder. It decomposes water slowly at common temperatures, and rapidly at a red heat. Pure oxyde of manganese can be reduced to the metallic state only in small quantities, by mixing it with lamp black and oil into a dough, and exposing the mixture to the intense heat of a smith's forge, in a luted crucible; which must be shaken occasionally to favor the agglomeration of the particles into a button. Thus procured, it contains, however, a little carbon.

Manganese is susceptible of five degrees of oxygenation.

1. The *protoxyde* may be obtained from a solution of the sulphate by precipitation with carbonate of potash, and expelling the carbonic acid from the washed and dried carbonate, by calcination in a close vessel filled with hydrogen gas, taking care that no air have access during the cooling. It is a pale green powder, which slowly attracts oxygen from the air, and becomes brown; on which account it should be kept in glass tubes, containing hydrogen, and hermetically sealed. It consists of 77·57 metal and 22·43 oxygen. It forms with 24 per cent. of water a white hydrate; and with acids, saline compounds; which are white, pink, or amethyst colored. They have a bitter, acerb taste, and afford with hydrogenated sulphuret of ammonia a flesh-red precipitate, but with caustic alkalis, one which soon turns brown-red, and eventually black.

2. The *deutoxyde of manganese* exists native in the mineral called *Braunite*; but it may be procured either by calcining, at a red heat, the proto-nitrate, or by spontaneous oxydizement of the protoxyde in the air. It is black; when finely pulverized, dark brown, and is convertible, on being heated in acids, into protoxyde, with disengagement of oxygen gas. It consists of 69·75 metal, and 30·25 oxygen. It forms, with 10 per cent. of water, a liver-brown hydrate, which occurs native under the name of *Manganite*. It dissolves readily in tartaric and citric acids, but in few others. This oxyde constitutes a bronze ground in calico-printing.

3. *Peroxyde of manganese; Braunstein*, occurs abundantly in nature. It gives out oxygen freely when heated, and becomes an oxydulated deutoxyde. It consists of 63·36 metal, and 36·64 oxygen.

4. *Manganesic acid* forms green-colored salts, but has not hitherto been insulated from the bases. It consists of 53·55 metal, and 46·45 oxygen.

5. *Hypermanganesic acid* consists of 49·70 metal, and 50·30 oxygen.

Ores of manganese.—There are two principal ores of this metal which occur in great masses; the peroxyde and the hydrated oxyde; the first of which is frequently found in primitive formations.

1. *Metalloide oxyde of manganese; pyrolusite,* or gray manganese ore; has a metallic lustre, a steel gray color, and affords a black powder. Spec. grav. 4·85. Scratches calc-spar. It effervesces briskly with borax at the blow-pipe, in consequence of the disengagement of oxygen gas. This is the most common ore of manganese, and a very valuable one, being the substance mostly employed in the manufacture of chloride of lime and of flint-glass. It is the peroxyde. Great quantities are found near Tavistock, in Devonshire, and Launceston, in Cornwall.

2. *Braunite,* is a dark brown substance, of a glassy metallic lustre, affording a brown powder. Spec. grav. 4·8. It scratches feldspar; but is scratched by quartz. Infusible at the blow-pipe, and effervesces but slightly when fused with glass of borax. It is the deutoxyde. It gives out at a red heat only 3 per cent. of oxygen.

3. *Manganite,* or hydroxyde of manganese; is brownish-black or iron-black, powder brown, with somewhat of a metallic lustre. Spec. grav. 4·3. Scratches fluor spar; affords water by calcination in a glass tube; infusible at the blow-pipe; and effervesces slightly when fused with glass of borax. It consists of about 90 of deutoxyde, and 10 of water.

4. *Haussmanite, black braunstein;* is brownish-black, affords a reddish-brown powder. Spec. grav. 4·7; scratches fluor spar; infusible at the blow-pipe; does not effervesce when fused with borax. It is a deutoxyde. This is a rare mineral, and of no value to the arts.

5. *Barytic oxyde of manganese; fibrous wad.* It is a combination of deutoxyde and peroxyde, with some baryta.

6. *Manganese blende,* or sulphuret of manganese; has a metallic aspect; is black, or dark steel gray; spec. grav. 3·95; has no cleavage; cannot be cut; infusible, but affords after being roasted distinct evidence of manganese, by giving a violet tinge to soda at the blow-pipe. Soluble in nitric acid; solution yields a white precipitate with the ferro-cyanide of potassium. It consists of sulphur 53·65; manganese 66·35.

7. *Carbonate of manganese; dialogite.* Spec. grav. 3·4; affords a green frit by fusion with carbonate of soda; is soluble with some effervescence in nitric acid; solution when freed from iron by succinate of ammonia, gives a white precipitate, with ferrocyanide of potassium. It consists of 28 carbonic acid, 56 protoxyde of mangancse, 5·4 of lime, 4·5 protoxyde of iron, and 0·8 magnesia.

8. *Hydrosilicate of manganese* is a black metallic looking substance, which yields a yellowish-brown powder, and water by calcination; is acted upon by muriatic acid, but affords no chlorine. It consists of silica 25; protoxyde of manganese 60; water 13.

9. *Ferriferous phosphate of manganese* is brown or black. Spec. grav. 3·6; scratches fluor; affords by calcination a very little of an acid water which corrodes glass; very fusible at the blow-pipe into a black metalloid magnetic bead; is acted upon by nitric acid; solution lets fall a blue precipitate with ferrocyanide of potassium; which tested by soda is shown to be manganese. It consists of phosphoric acid 32·78; protoxyde of iron 31·90; protoxyde of manganese 32·60; phosphate of lime 3·2. Another phosphate called *hureaulite,* contains 38 of phosphoric acid; 11·10 of protoxyde of iron; 32·85 of protoxyde of manganese, and 18 of water.

Black wad, is the old English name of the hydrated peroxyde of manganese. It occurs in various imitative shapes, in froth-like coatings upon other minerals, as also massive. Some varieties possess imperfect metallic lustre. The external color is brown of various shades, and similar in the streak, only shining. It is opaque, very sectile, soils and writes. Its specific gravity is about 3·7. Mixed with linseed oil into a dough, black wad forms a mass that spontaneously inflames. A variety from the Hartz, analyzed by Klaproth, afforded peroxyde of manganese 68; oxyde of iron 6·5; water 17·5; carbon 1; barytes and silica 9. The localities of black wad are particularly Cornwall and Devonshire, the Hartz, and Piedmont. I have analyzed many varieties of the black wad sold to the manufacturers of bleaching salt and flint glass, and have found few of them so rich in peroxyde of manganese as the above. Very generally they contained no less than 25 *per cent.* of oxyde of iron, 8 or 9 of silica, about 7 of water, and the remainder amounting to only 60 *per cent.* of the peroxyde.

M. Gay Lussac has proposed to determine the commercial value of manganese ore, by the quantity of chlorine which it affords when treated with liquid muriatic acid. He places the manganese powder in a small retort or matrass, pours over it the acid, and the chlorine being disengaged with the aid of a gentle heat, is transmitted into a vessel containing milk of lime or potash water. This liquor is thereafter poured into a dilute solution of sulphate of indigo; and the quantity of chlorine is inferred from the quantity of the blue solution which is decolored. I pass the chlorine into test solution of indigo.

The manufacturer of flint glass uses a small proportion of the black manganese ore, to correct the green tinge which his glass is apt to derive from the iron present in the sand he employs. To him it is of great consequence to get a native manganese containing as little iron oxyde as possible; since in fact the color or limpidity of his product will depend altogether upon that circumstance.

Sulphate of manganese has been of late years introduced into calico-printing, to give a chocolate or bronze impression. It is easily formed by heating the black oxyde, mixed with a little ground coal, with sulphuric acid. See CALICO-PRINTING.

The peroxyde of manganese is used also in the formation of glass pastes, and in making the black enamel of pottery. See OXALIC ACID.

MANGLE. (*Calandre*, Fr; *Mangel*, Germ.) This is a well known machine for smoothing table cloths, table napkins, as well as linen and cotton furniture. As usually made, it consists of an oblong rectangular wooden chest, filled with stones, which load it to the degree of pressure that it should exercise upon the two cylinders on which it rests, and which, by rolling backwards and forwards over the linen spread upon a polished table underneath, render it smooth and level. The moving wheel, being furnished with teeth upon both surfaces of its periphery, and having a notch cut out at one part, allows a pinion, uniformly driven in one direction, to act alternately upon its outside and inside, so as to cause the reciprocating motion of the chest. This elegant and much admired English invention, called the mangle-wheel, has been introduced with great advantage into the machinery of the textile manufactures.

Mr. Warcup, of Dartford, obtained a patent several years ago for a mangle, in which the linen, being rolled round a cylinder revolving in stationary bearings, is pressed downwards by heavy weights hung upon its axes, against a curved bed, made to slide to and fro, or traverse from right to left, and left to right, alternately.

Mr. Hubie, of York, patented in June, 1832, another form of mangle, consisting of three rollers, placed one above another in a vertical frame, the axle of the upper roller being pressed downwards by a powerful spring. The articles intended to be smoothed are introduced into the machine by passing them under the middle roller, which is made to revolve by means of a fly wheel; the pinion upon whose axis works in a large toothed wheel fixed to the shaft of the same roller. The linen, &c. is lapped as usual in protecting cloths. This machine is merely a small CALENDER.

MANIOC is the Indian name of the nutritious matter of the shrub *jatropha manihot*, from which *cassava* and *tapioca* are made in the West Indies.

MANNA is the concrete saccharine juice of the *Fraxinus ornus*, a tree much cultivated in Sicily and Calabria. It is now little used, and that only in medicine.

MARBLE. This title embraces such of the primitive, transition, and purer compact limestones of secondary formation, as may be quarried in solid blocks without fissures, and are susceptible of a fine polished surface. The finer the white, or more beautifully variegated the colors of the stone, the more valuable, *cæteris paribus*, is the marble. Its general characters are the following:—

Marble effervesces with acids; affords quicklime by calcination; has a conchoidal scaly fracture; is translucent only on the very edges; is easily scratched by the knife; has a spec. grav. of 2·7; admits of being sawn into slabs, and receives a brilliant polish. These qualities occur united in only three principal varieties of limestone; in the saccharoid limestone, so called from its fine granular texture resembling that of loaf sugar, and which constitutes modern statuary marble, like that of Carrara; 2. in the foliated limestone, consisting of a multitude of small facets formed of little plates applied to one another in every possible direction, constituting the antique statuary marble, like that of Paros; 3. in many of the transition and carboniferous, or *encrinitic* limestones, subordinate to the coal formation.

The saccharoid and lamellar, or statuary marbles, belong entirely to primitive and transition districts. The greater part of the close-grained colored marbles belong also to the same geological localities; and become so rare in the secondary limestone formations, that immense tracts of these occur without a single bed sufficiently entire and compact to constitute a workable marble. The limestone lying between the calcareo-silicious sands and gritstone of the under oolite, and which is called Forest marble in England, being susceptible of a tolerable polish, and variegated with imbedded shells, has sometimes been worked into ornamental slabs in Oxfordshire, where it occurs in the neighborhood of Whichwood forest; but this case can hardly be considered as an exception to the general rule. To constitute a profitable marble-quarry, there must be a large extent of homogeneous limestone, and a facility of transporting the blocks after they are dug. On examining these natural advantages of the beds of Carrara marble, we may readily understand how the statuary marbles discovered in the Pyrenees, Savoy, Corsica, &c. have never been able to come into competition with it in the market. In fact, the two sides of the valley of Carrara may be regarded as mountains of statuary marble of the finest quality.

Gypseous alabaster may be readily distinguished from marbles, because it does not effervesce with acids, and is soft enough to be scratched by the nail; stalagmitic alabaster is somewhat harder than marble, translucent, and variegated with regular stripes or undulations.

Some granular marbles are flexible in thin slabs, or, at least, become so by being dried at the fire; which shows, as Dolomieu suspected, that this property arises from a diminution of the attractive force among the particles, by the loss of the moisture.

The various tints of ornamental marbles generally proceed from oxydes of iron; but the blue and green tints are sometimes caused by minute particles of hornblende, as in the slate-blue variety called Turchino, and in some green marbles of Germany. The black marbles are colored by charcoal, mixed occasionally with sulphur and bitumen; when they constitute stinkstone.

Brard divides marbles, according to their localities, into classes, each of which contains eight subdivisions:—

1. Uni-colored marbles; including only the white and the black.
2. Variegated marbles; those with irregular spots or veins.
3. Madreporic marbles, presenting animal remains in the shape of white or gray spots, with regularly disposed dots and stars in the centre.
4. Shell marbles; with only a few shells interspersed in the calcareous base.
5. Lumachella marbles, entirely composed of shells.
6. Cipolin marbles, containing veins of greenish talc.
7. Breccia marbles, formed of a number of angular fragments of different marbles, united by a common cement.
8. Puddingstone marbles; a conglomerate of rounded pieces.

Antique marbles.—The most remarkable of these are the following:—*Parian marble*, called *lychnites* by the ancients, because its quarries were worked by lamps; it has a yellowish-white color; and a texture composed of fine shining scales, lying in all directions. The celebrated Arundelian tables at Oxford consist of Parian marble, as well as the Medicean Venus. *Pentelic marble*, from Mount Penteles, near Athens, resembles the Parian, but is somewhat denser and finer grained, with occasional greenish zones, produced by greenish talc, whence it is called by the Italians *Cipolino statuario.* The Parthenon, Propyleum, the Hippodrome, and other principal monuments of Athens, were of Pentelic marble; of which fine specimens may be seen among the Elgin collection, in the British Museum. *Marmo Greco*, or Greek white marble, is of a very lively snow white color, rather harder than the preceding, and susceptible of a very fine polish. It was obtained from several islands of the Archipelago, as Scio, Samos, Lesbos, &c. *Translucent white marble, Marmo statuario* of the Italians, is very much like the Parian, only not so opaque. Columns and altars of this marble exist in Venice, and several towns of Lombardy; but the quarries are quite unknown. *Flexible white marble*, of which five or six tables are preserved in the house of Prince Borghese, at Rome. The *white marble of Luni*, on the coast of Tuscany, was preferred by the Greek sculptors to both the Parian and Pentelic. *White marble of Carrara*, between Specia and Lucca, is of a fine white color, but often traversed by gray veins, so that it is difficult to procure moderately large pieces free from them. It is not so apt to turn yellow as the Parian marble. This quarry was worked by the ancients, having been opened in the time of Julius Cæsar. Many antique statues remain of this marble. Its two principal quarries at the present day are those of Pianello and Polvazzo. In the centre of its blocks very limpid rock-crystals are sometimes found, which are called Carrara diamonds. As the finest qualities are becoming excessively rare, it has risen in price to about 3 guineas the cubic foot. The *White marble* of Mount Hymettus, in Greece, was not of a very pure white, but inclined a little to gray. The statue of Meleager, in the French Museum, is of this marble.

Black antique marble, the *Nero antico* of the Italians. This is more intensely black than any of our modern marbles; it is extremely scarce, occurring only in sculptured pieces. The *red antique marble, Egyptum* of the ancients, and *Rosso antico* of the Italians, is a beautiful marble of a deep blood-red color, interspersed with white veins and with very minute white dots, as if strewed over with grains of sand. There is in the Grimani palace at Venice, a colossal statue of Marcus Agrippa in *rosso antico*, which was formerly preserved in the Pantheon at Rome. *Green antique marble, verde antico*, is a kind of breccia, whose paste is a mixture of talc and limestone, while the dark green fragments consist of serpentine. Very beautiful specimens of it are preserved at Parma. The best quality has a grass-green paste, with black spots of noble serpentine, but is never mingled with red spots. *Red spotted green antique marble*, has a dark green ground marked with small red and black spots, with fragments of *entrochi* changed into white marble. It is known only in small tablets. *Leek marble*; a rare variety of that color, of which there is a table in the Mint at Paris. *Marmo verde pagliocco* is of a yellowish green color, and is found only in the ruins of ancient Rome. *Cervelas marble* of a deep red, with numerous gray and white veins, is said to be found in Africa, and highly esteemed in commerce. *Yellow antique marble*, *giallo antico* of the Italians; color of the yolk of an egg, either uniform or marked with black or deep yellow rings. It is rare, but may be replaced by Sienna marble. *Red and white antique marbles*, found only among the ruins of ancient Rome. *Grand antique*, a breccia marble, containing shells, consists of large fragments of a black marble, traversed by veins or lines of a shining white. There are four columns of it in the Museum at Paris. *Antique Cipolino marble.* Cipolin is a name given to all such marbles as have greenish zones produced by green talc; their fracture is granular and shining, and displays here and there plates of talc. *Purple antique breccia marble*, is very variable in the color and size of its spots. *Antique African breccia* has a black ground, variegated with large fragments of a grayish-white, deep red, or purplish wine color; and is one of the most beautiful marbles. *Rose-colored antique breccia* marble is very scarce, occurring only in small tablets. There are various other kinds of ancient breccias, which it would be tedious to particularize.

Modern marbles.—1. British. Black marble is found at Ashford, Matlock, and Monsaldale in Derbyshire; black and white in the north part of Devonshire; the variegated marbles of Devonshire are generally reddish, brownish, and grayish, variously veined with white and yellow, or the colors are often intimately blended; the marbles from Torbay and Babbacombe, display a great variety in the mixture of their colors; the Plymouth marble is either ash-colored with black veins, or blackish-gray and white, shaded with black veins; the cliffs near Marychurch exhibit marble quarries not only of great extent, but of superior beauty to any other in Devonshire, being either of a dove-colored ground with reddish-purple and yellow veins, or of a black ground mottled with purplish globules. The green marble of Anglesea is not unlike the *verde antico*; its colors being greenish-black, leek-green, and sometimes dull purplish, irregularly blended with white. The white part is limestone, the green shades proceed from serpentine and asbestos. There are several fine varieties of marble in Derbyshire; the mottled-gray in the neighborhood of Moneyash, the light gray being rendered extremely beautiful by the number of purple veins which spread upon its polished surface in elegant irregular branches; but its chief ornament is the multitude of *entrochi*, with which this transition limestone-marble abounds. Much of the transition and carboniferous limestone of Wales and Westmoreland is capable of being worked up into agreeable dark marbles.

In Scotland, a particularly fine variety of white marble is found in immense beds, at Assynt in Sutherlandshire. A beautiful ash-gray marble of a very uniform grain, and susceptible of a fine polish, occurs on the north side of the ferry of Ballachulish in Invernesshire. One of the most beautiful varieties is that from the hill of Belephetrich in Tiree, one of the Hebrides. Its colors are pale blood-red, light flesh-red, and reddish-white, with dark green particles of hornblende, or rather sahlite, diffused through the general base. The compact marble of Iona is of a fine grain, a dull white color, somewhat resembling pure compact feldspar. It is said by Bournon, to consist of an intimate mixture of tremolite and carbonate of lime, sometimes with yellowish or greenish-yellow spots. The carboniferous limestone of many of the coal basins in the lowlands of Scotland may be worked into a tolerably good marble for chimney-pieces.

In Ireland, the Kilkenny marble is the one best known, having a black ground more or less varied with white marks produced by petrifactions. The spar which occupies the place of the shells, sometimes assumes a greenish-yellow color. An exceedingly fine black marble has also been raised at Crayleath in the county of Down. At Louthlougher, in the county of Tipperary, a fine purple marble is found, which when polished looks very beautiful. The county of Kerry affords several variegated marbles, not unlike the Kilkenny.

France possesses a great many marble quarries which have been described by Brard, and of which a copious abstract is given under the article marble—*Rees' Cyclopedia.*

The territory of Genoa furnishes several beautiful varieties of marble, the most remarkable of which is the *polzevera di Genoa*, called in French the *vert d'Egypte* and *vert de mer*. It is a mixture of granular limestone with a talcose and serpentine substance disposed in veins; and it is sometimes mixed with a reddish body. This marble was formerly much employed in Italy, France, and England, for chimney-pieces, but its sombre appearance has put it out of fashion.

Corsica possesses a good statuary marble of a fine close grain, and pure milky whiteness, quarried at Ornofrio; it will bear comparison with that of Carrara; also a gray marble (*bardiglio*), a cipolin, and some other varieties. The island of Elba has immense quarries of a white marble with blackish-green veins.

Among the innumerable varieties of Italian marbles, the following deserve especial notice.

The *rovigio*, a white marble found at Padua; the white marble of St. Julien, at Pisa, of which the cathedral and celebrated slanting tower are built; the Biancone marble, white with a tinge of gray, quarried at Maguregа for altars and tombs. Near Mergozza the white saline marble with gray veins is found; with which the cathedral of Milan is built. The black marble of Bergamo is called *paragone*, from its black color, like touchstone; it has a pure intense tint, and is susceptible of a fine polish. The pure black marble of Como is also much esteemed. The *polveroso* of Pistoya, is a black marble sprinkled with dots; and the beautiful white marble with black spots, from the Lago Maggiore, has been employed for decorating the interior of many churches in the Milanese. The Margorre marble found in several parts of the Milanese, is bluish veined with brown, and composes part of the dome of the cathedral of Milan. The green marble of Florence owes its color to a copious admixture of steatite. Another green marble, called *verde di Prado*, occurs in Tuscany, near the little town of Prado. It is marked with spots of a deeper green than the rest, passing even into blackish-blue. The beautiful Sienna marble, or *brocatello di Siena*, has a yellow color like the yolk of an egg, which is disposed in large irregular spots, surrounded with veins of bluish-red, passing sometimes into purple. At Montarenti, two leagues from Sienna, another yellow marble is met with, which is traversed by black and purplish-black veins. The Brema marble is yellow with white spots. The *mandelato* of the Italians is a light red marble with yellowish-white spots, found at Luggezzana, in the Veronese. The red marble of Verona is of a red rather inclining to yellow or hyacinth; a second variety of a dark red, composes the vast amphitheatre of Verona. Another marble is found near Verona, with large white spots in a reddish and greenish paste. Very fine columns have been made of it. The *occhio di pavone* is an Italian shell marble, in which the shells form large orbicular spots, red, white, and bluish. A madreporic marble known under the name of *pietra stellaria*, much employed in Italy, is entirely composed of star madrepores, converted into a gray and white substance, and is susceptible of an excellent polish. The village of Bretonico, in the Veronese, furnishes a splendid breccia marble, composed of yellow, steel-gray, and rose-colored spots. That of Bergamo consists of black and gray fragments in a greenish cement. Florence marble, called also ruin and landscape marble, is an indurated calcareous marl.

Sicily abounds in marbles, the most valuable of which is that called by the English stone-cutters, Sicilian jasper; it is red with large stripes like ribands, white, red, and sometimes green, which run zigzag with pretty acute angles.

Among the Genoese marbles we may notice the highly esteemed variety called *portor*, on account of the brilliant yellow veins in a deep black ground. The most beautiful kind comes from Porto-Venese, and Louis XIV. caused a great deal of it to be worked up for the decoration of Versailles. It costs now two pounds per cubic foot.

Of cutting and polishing marble.—The marble saw is a thin plate of soft iron, continually supplied during its sawing motion, with water and the sharpest sand. The sawing of moderate pieces is performed by hand, but that of large slabs is most economically done by a proper mill.

The first substance used in the polishing process is the sharpest sand, which must be worked with till the surface becomes perfectly flat. Then a second, and even a third sand of increasing fineness is to be applied. The next substance is emery of progressive degrees of fineness, after which tripoli is employed; and the last polish is given with tin-putty. The body with which the sand is rubbed upon the marble, is usually a plate of iron; but for the subsequent process, a plate of lead is used with fine sand and emery. The polishing rubbers are coarse linen cloths, or bagging, wedged tight into an iron planing tool. In every step of the operation, a constant trickling supply of water is required.

Visiters of Derby may have an opportunity of inspecting Brown's extensive machinery for cutting marble into many ornamental forms, which has been well described in Rees' Cyclopedia.

Sir James Jelf patented, in 1822, a combination of machinery for cutting any description of parallel mouldings upon marble slabs, for ornamental purposes; in which tools, supplied with sand and water, are made to traverse to and fro.

Mr. Tullock obtained a patent, in 1824, for improvements in machinery for sawing and grooving marble; the power being applied by means of toothed wheels bearing cranks, which gave the see-saw motion to the cutting iron plates.

In November, 1829, Mr. Gibbs secured, by patent, an invention for working ornamental devices in marble, by means of a travelling drill, guided by a mould of wood, &c., in counter relief; and in April, 1833, Mr. G. W. Wilds obtained a patent for machinery, which consists of a series of circular cutters, for separating slabs from a block of marble; the block being advanced slowly to meet the cutters, by the progressive movement of a platform upon wheels, driven by the agency of a rack and pinion, as in the cylinder boring machine of the steam-engine manufacturer. Sand and water must be supplied, of course, from a hopper, to these smooth cutting discs of iron or copper. See Glass-Cutting. He proposes also to mould and polish marble, by applying a rotatory wheel or cylinder of any shape to it, in its carrying frame.

MARCASITE is a variety of iron pyrites, containing generally a little arsenic.

MARGARATES are saline compounds of margaric acid with the bases.

MARGARIC ACID is one of the acid fats, produced by saponifying tallow with alkaline matter, and decomposing the soap with dilute acid. The term Margaric signifies Pearly-looking.

The physical properties of the margaric and stearic acids are very similar; the chief difference is that the former is more fusible, melting at 140° F. The readiest mode of obtaining pure margaric acid, is to dissolve olive oil soap in water, to pour into the solution a solution of neutral acetate of lead, to wash and dry the precipitate, and then to remove its oleate of lead by ether, which does not affect its margarate of lead. The residuum being decomposed by boiling hot muriatic acid, affords margaric acid. When heated in a retort this acid boils. It is insoluble in water, very soluble in alcohol and ether; it reddens litmus paper, and decomposes, with the aid of heat, the carbonates of soda and potash.

MARINE ACID. See Muriatic Acid.

MARINE SALT. See Salt.

MARL (*Marne*, Fr.; *Mergel*, Germ.) is a mixed earthy substance, consisting of carbonate of lime, clay, and silicious sand, in very variable proportions; it is sometimes compact, sometimes pulverulent. According to the predominance of one or other of these three main ingredients, marls may be distributed into calcareous, clayey, and sandy. See Limestone.

MARQUETRY is a peculiar kind of cabinet work, in which the surface of wood is ornamented with inlaid pieces of various colors and forms. The *marqueteur* puts gold, silver, copper, tortoise-shell, mother-of-pearl, ivory, horn, &c. under contribution. These substances, being reduced to laminæ of proper thinness, are cut out into the desired forms by punches, which produce at once the full pattern or mould, and the empty one, which enclosed it; and both serve their separate purposes in marquetry. For the methods of dyeing the woods, &c. see Ivory.

MARTIAL signifies, belonging to iron; from Mars, the mythological name of this metal.

MASSICOT is the yellow oxyde of lead.

MASTIC (Eng. and Fr.; *Mastix*, Germ.) is a resin produced by making incisions in the *Pistacia Lentiscus*, a tree cultivated in the Levant, and chiefly in the island of Chios. It comes to us in yellow, brittle, transparent, rounded tears; which soften between the teeth; with bitterish taste and aromatic smell, and a specific gravity of 1·07. Mastic consists of two resins; one soluble in dilute alcohol; but both dissolve in strong alcohol. Its solution in spirit of wine constitutes a good varnish. It dissolves also in oil of turpentine. See Varnish.

MATRASS is a bottle with a thin egg-shaped bottom, much used for digestions in chemical researches.

MATTE is a crude black copper reduced, but not refined from sulphur and other heterogeneous substances.

MEADOW ORE is conchoidal bog iron ore.

MEDALS. For their composition, see Bronze and Copper.

MEERSCHAUM (Germ.; *sea-froth*, Eng.; *Ecume de Mer, Magnésie carbonatée silicifère*, Fr.) is a white mineral, of a somewhat earthy appearance, always soft, but dry to the touch, and adhering to the tongue. Specific gravity, 2·6 to 3·4; affords water by calcination; fuses with difficulty at the blowpipe into a white enamel; and is acted upon by acids. It consists, according to Klaproth, of silica, 41·5; magnesia, 18·25; water and carbonic acid, 39. Other analysts give, silica 50, magnesia 25, water 25. It occurs in veins or kidney-shaped nodules, among rocks of serpentine, at Egribos, in the island of Negropont, Eski-Schehir in Anatolia, Brussa at the foot of Mount Olympus, at Baldissero in Piedmont, in the serpentine veins of Cornwall, &c.

When first dug up, it is soft, greasy, and lathers like soap; and is on that account used by the Tartars in washing their linen. The well-known Turkey tobacco-pipes are made from it, by a process analogous to that for making pottery ware. The bowls of the pipes, when imported into Germany, are prepared for sale by soaking them first in tallow, then in wax, and finally by polishing them with shave-grass.

MELLITE. (Eng. and Fr.; *Honigstein*, Germ.) See Honeystone.

MELLITIC ACID, which is associated with alumina in the preceding mineral, crystallizes in small colorless needles, is without smell, of a strongly acid taste, permanent in the air, soluble in water and alcohol, as also in boiling hot concentrated sulphuric acid, but is decomposed by hot nitric acid, and consists of 50·21 carbon, and

49·79 oxygen. It is carbonized at a red heat, without the production of any inflammable oil.

MELLON is a new compound of carbon and azote, discovered by M. Liebig, by heating bi-sulpho-cyanide of mercury. The mellon remains at the bottom of the retort under the form of a yellow powder.

MENACHANITE, an ore of *titanium*, found in the bed of a rivulet which flows into the valley Menacan, in Cornwall.

MERCURY or QUICKSILVER. This metal is distinguished by its fluidity at common temperatures; its density = 13·6; its silver blue lustre; and its extreme mobility. A cold of 39° below zero of Fahrenheit, or —40° Cent., is required for its congelation, in which state its density is increased in the proportion of 10 to 9, or it becomes of spec. grav. 15·0. At a temperature of 656° F. it boils and distils off in an elastic vapor; which, being condensed by cold, forms purified mercury.

Mercury combines with great readiness with certain metals, as gold, silver, zinc, tin, and bismuth, forming, in certain proportions, fluid solutions of these metals. Such mercurial alloys are called *amalgams*. This property is extensively employed in many arts; as in extracting gold and silver from their ores; in gilding, plating, making looking-glasses, &c. Humboldt estimates at 16,000 quintals, of 100 lbs. each, the quantity of mercury annually employed at his visit to America, in the treatment of the mines of New Spain; three fourths of which came from European mines.

The mercurial ores may be divided into four species:—

1. *Native quicksilver.*—It occurs in most of the mines of the other mercurial ores, in the form of small drops attached to the rocks, or lodged in the crevices of other ores.

2. *Argental mercury, or native silver amalgam.*—It has a silver white color, and is more or less soft, according to the proportion which the mercury bears to the silver. Its density is sometimes so high as 14. A moderate heat dissipates the mercury, and leaves the silver. Klaproth states its constituents at silver 36, and mercury 64, in 100; but Cordier makes them to be, 27½ silver, and 72½ mercury. It occurs crystallized in a variety of forms. It has been found in the territory of Deux-Ponts, at Rozenau and Niderstana, in Hungary, in a canton of Tyrol, at Sahlberg in Sweden, at Kolyvan in Siberia, and at Allemont in Dauphiny; in small quantity at Almaden in Spain, and at Idria in Carniola. By the chemical union of the mercury with the silver, the amalgam, which should by calculation have a spec. grav. of only 12·5, acquires that of 14·11, according to M. Cordier.

3. *Sulphuret of mercury*, commonly called Cinnabar, is a red mineral of various shades; burning at the blowpipe with a blue flame, volatilizing entirely with the smell of burning sulphur, and giving a quicksilver coating to a plate of copper held in the fumes. Even the powder of cinnabar rubbed on copper whitens it. Its density varies from 6·9 to 10·2. It becomes negatively electrical by friction. Analyzed by Klaproth, it was found to consist of mercury 84·5, sulphur 14·75. Its composition, viewed as a bisulphuret of mercury, is, mercury 86·2, sulphur 13·8. The finest crystals of sulphuret of mercury come from China, and Almaden in Spain. These contain, according to Klaproth, 85 per cent. of mercury.

A *bituminous sulphuret of mercury* appears to be the base of the great exploration of Idria; it is of a dark liver-red hue; and of a slaty texture, with straight or twisted plates. It exists in large masses in the bituminous schists of Idria. M. Beurard mentions also the locality of Munster-Appel, in the dutchy of Deux-Ponts, where the ore includes impressions of fishes, curiously spotted with cinnabar.

The compact variety of the Idria ore seems very complex in composition, according to the following analysis of Klaproth:—Mercury, 81·8; sulphur, 13·75; carbon, 2·3; silica, 0·65; alumina, 0·55; oxyde of iron, 0·20; copper, 0·02; water, 0·73; in 100 parts. M. Beurard mentions another variety from the Palatinate, which yields a large quantity of bitumen by distillation; and it was present in all the specimens of these ores analyzed by me for the German Mines Company. At Idria and Almaden the sulphurets are extremely rich in mercury.

4. *Muriated mercury*, or the *Chloride of mercury*, commonly called Horn mercury. This ore occurs in very small crystals of a pearl-gray or greenish-gray color, or in small nipples which stud, like crystals, the cavities, fissures, or geodes among the ferruginous gangues of the other ores of mercury. It is brittle, and entirely volatile at the blow-pipe, characters which distinguish it from horn silver.

The geological position of the mercurial ores, in all parts of the world, is in the strata which commence the series of secondary formations. Sometimes they are found in the red sandstone above the coal, as at Menildot, in the old dutchy of Deux-Ponts, at Durasno in Mexico, at Cuença in New Granada, at Cerros de Gauzan and Upar in Peru; in the subordinate porphyries, as at Deux-Ponts, San Juan de la Chica in Peru, and at Cerro-del-Fraile, near the town of San Felipe; they occur also among the strata below, or subordinate to the calcareous formation, called zechstein, in Germany, or among the accompanying bituminous schists, as at Idria in Carniola; and, lastly, they form masses in the zechstein itself. Thus, it appears that the mercurial depoaites are confined within very narrow geological limits, between the calcareous beds of zechstein, and the red sandstone. They occur at times in carbonaceous nodules, derived from the decomposition of mosses of various kinds; and the whole mercurial depoaite is occasionally covered with beds of charcoal, as at Durasno.

They are even sometimes accompanied with the remains of organic bodies, such as casts of fishes, fossil shells, silicified wood, and true coal. The last fact has been observed at Potzberg, in the works of Drey-Koenigszug, by M. Brongniart. These sandstones, bituminous schists, and indurated clays, contain mercury both in the state of sulphuret and in the native form. They are more or less penetrated with the ore, forming sometimes numerous beds of very great thickness; while, in the more ancient or the primitive formations, these ores exist only in very small quantity associated with tin. Mercury is, generally speaking, a metal sparingly distributed in nature, and its mines are very rare.

The great exploitations of Idria in Friuli, in the county of Goritz, were discovered in 1497, and the principal ore mined there is the bituminous sulphuret. The workings of this mine have been pushed to the depth of 280 yards. The product in quicksilver might easily amount annually to 6000 metric quintals=600 tons British; but, in order to uphold the price of the metal, the Austrian government has restricted the production to 150 tons. The memorable fire of 1803 was most disastrous to these mines. It was extinguished only by drowning all the underground workings. The sublimed mercury in this catastrophe occasioned diseases and nervous tremblings to more than 900 persons in the neighborhood.

Pliny has recorded two interesting facts: 1. that the Greeks imported red cinnabar from Almaden 700 years before the Christian era; and 2. that Rome, in his time, annually received 700,000 pounds from the same mines. Since 1827, they have produced 22,000 cwts. of mercury every year, with a corps of 700 miners and 200 smelters; and, indeed, the veins are so extremely rich, that though they have been worked pretty constantly during so many centuries, the mines have hardly reached the depth of 330 yards, or something less than 1000 feet. The lode actually under exploration is from 14 to 16 yards thick; and it becomes thicker still at the crossing of the veins. The totality of the ore is extracted. It yields in their smelting works only 10 per cent. upon an average, but there is no doubt, from the analysis of the ores, that nearly one half of the quicksilver is lost, and dispersed in the air, to the great injury of the workmen's health, in consequence of the barbarous apparatus of aludels employed in its sublimation; an apparatus which has remained without any material change for the better since the days of the Moorish dominion in Spain. M. Le Play, the eminent *Ingenieur des Mines*, who published, in a recent volume of the Annales des Mines, his *Itinéraire* to Almaden, says, that the mercurial contents of the ores are *notablement plus elevées* than the product.

These veins extend all the way from the town of Chillon to Almadenejos. Upon the borders of the streamlet Balde Azogues, a black slate is also mined which is abundantly impregnated with metallic mercury. The ores are treated in 13 double furnaces, which I shall presently describe. "Le mercure," says M. Le Play, "a sur la santé des ouvriers la plus funeste influence, et l' on ne peut se défendre d' un sentiment pénible en voyant l' empressement avec lequel des jeunes gens, pleins de force et de santé, se disputent la faveur d' aller chercher dans les mines, des maladies cruelles, et souvent une mort prématurée. La population des mineurs d' Almaden méritent le plus haut interét." These victims of a deplorable mismanagement are described as being a laborious, simple-minded, virtuous race of beings, who are thus condemned to breathe an atmosphere impregnated far and near with the fumes of a volatile poison, which the lessons of science, as I shall presently demonstrate, might readily repress, with the effect of not only protecting the health of the population, but of vastly augmenting the revenues of the state.

These celebrated mines, near to which lie those of *Las Cuebas* and of *Almadenejos*, were known to the Romans. After having been the property of the religious knights of *Calatrava*, who had assisted in expelling the Moors, they were farmed off to the celebrated *Fugger* merchants of Augsbourg; and afterwards explored on account of the government, from the date of 1645 till the present time. Their produce was, till very lately, entirely appropriated to the treatment of the gold and silver ores of the new world.

The mines of the *Palatinate*, situated on the left bank of the Rhine, though they do not approach in richness and importance to those of Idria and Almaden, merit, however, all the attention of the government that farms them out. They are numerous, and varied in geological position. Those of Drey-Koenigszug, at Potzberg, near Kussel, deserve particular notice. The workings have reached a depth of more than 220 yards; the ore being a sandstone strongly impregnated with sulphuret of mercury. The produce of these *mines is estimated* at about 30 tons per annum.

There are also in Hungary, Bohemia, and several other parts of Germany, some inconsiderable exploitations of mercury, the total produce of which is valued at about 30 or 40 tons on an average of several years.

The mines of Guancavelica, in Peru, are the more interesting, as their products are directly employed in treating the ores of gold and silver, which abound in that portion of America. These quicksilver mines, explored since 1570, produced, up to 1800, 53,700 tons of that metal; but the actual produce of the explorations of these countries was, according to Helms, about the beginning of this century, from 170 to 180 tons per annum.

In 1782, recourse was had by the South American miners to the mercury extracted in the province of Yun-nan, in China.

The metallurgic treatment of the quicksilver ores is tolerably simple. In general, when the sulphuret of mercury, the most common ore, has been pulverized, and sometimes washed, it is introduced into retorts of cast-iron, sheet-iron, or even stoneware, in mixture with an equal weight of quicklime. These retorts are arranged in various ways.

Prior to the 17th century, the method called *per descensum* was the only one in use for distilling mercury; and it was effected by means of two earthen pots adjusted over each other. The upper pot, filled with ore, and closed at the top, was covered over with burning fuel; and the mercurial vapors expelled by the heat, passed down through small holes in the bottom of the pot, to be condensed in another vessel placed below. However convenient this apparatus might be, on account of the facility of transporting it, wherever the ore was found, its inefficiency and the losses it occasioned were eventually recognised. Hence, before 1635, some smelting works of the Palatinate had given up the method *per descensum*, which was, however, still retained in Idria; and they substituted for it the furnaces called *galleries*. At first, earthenware retorts were employed in these furnaces; but they were soon succeeded by iron retorts. In the Palatinate this mode of operating is still in use. At Idria, in the year 1750, a great distillatory apparatus was established for the treatment of the mercurial ores, in imitation of those which previously existed at Almaden, in Spain, and called *aludel-furnaces*. But, since 1794, these aludels have been suppressed, and new distillatory apparatus have been constructed at Idria, remarkable only for their magnitude; exceeding, in this respect, every other metallurgic erection.

There exist, therefore, three kinds of apparatus for the distillation of mercury: 1. the furnace called a *gallery;* 2. the furnace with *aludels;* and 3. the *large apparatus* of Idria. I shall describe each of these briefly, in succession.

1. *Furnace called Gallery of the Palatinate.*—The construction of this furnace is disposed so as to contain four ranges, *a a′*, *b b′*, of large retorts, styled cucurbits, of cast-iron, in which the ore of mercury is subjected to distillation. This arrangement is shown in *fig.* 656, which presents a vertical section in the line *a b* of the ground plan, *fig.* 657. In the ground plan, the roof *e e′* of the furnace (*fig.* 656) is supposed to be lifted off, in order to show the disposition of the four ranges of cucurbits upon the grate c *f*, *figs.* 656, 657, which receives the pit-coal employed as fuel. Under this grate extends an ash-pit *d*. *Fig.* 658, which exhibits an elevation of the furnace, points out this ash-pit, as well as one of the two doors *c*, by which the fuel is thrown upon the grate c *f*. Openings *e e*, (*fig.* 656,) are left over the top arch of the furnace, whereby the draught of air may receive a suitable direction. The grate of the fireplace extends over the whole length of the furnace, *fig.* 657, from the door *c* to the door *f*, situated at the opposite extremity. The furnace called *gallery* includes commonly 30 cucurbits, and in some establishments even 52. Into each are introduced from 56 to 70 pounds of ore, and 15 to 18 pounds of quicklime, a mixture which fills no more than two thirds of the cucurbit; to the neck a stoneware receiver is adapted, containing water to half its height. The fire, at first moderate, is eventually pushed till the cucurbits are red hot. The operation being concluded, the contents of the receivers are poured out into a wooden bowl placed upon a plank above a bucket; the quicksilver falls to the bottom of the bowl, and the water draws over the *black mercury*, for so the substance that coats

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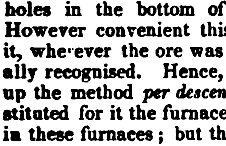

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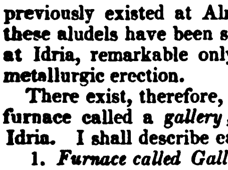

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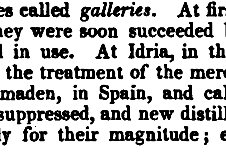

the inside of the receivers is called. This is considered to be a mixture of sulphuret and oxyde of mercury. The *black mercury*, taken out of the tub and dried, is distilled anew with excess of lime; after which the residuum in the retorts is thrown away, as useless.

Aludel furnaces of Almaden.—*Figs.* 659 and 660 represent the great furnaces with aludels in use at Almaden, and anciently in Idria; for between the two establishments there was in fact little difference before the year 1794. *Figs.* 659 and 662 present two vertical sections; *figs.* 660 and 661 are two plans of two similar furnaces, conjoined in one body of brickwork. In the four figures the following objects are to be remarked: a door *a*, by which the wood is introduced into the fire-place *b*. This is perforated with holes for the passage of air; the ash-pit c is seen beneath. An upper chamber, *d*, contains the mercurial ores distributed upon open arches, which form the perforated sole of this chamber. Immediately over these arches, there are piled up, in a dome form, large blocks of a limestone, very poor in quicksilver ore; above these are laid blocks of a smaller size, then ores of rather inferior quality, and stamped ores mixed with richer minerals. Lastly, the whole is covered up with soft bricks, formed of clay kneaded with *schlich*, and with small pieces of sulphuret of mercury. Six ranges of aludels or stoneware tubes *f f*, of a pear shape, luted together with clay, are mounted in front of each of the two furnaces, on a double sloping terrace, having in its lowest middle line two gutters *t v*, a little inclined towards the intermediate wall *m*. In each range the aludel placed at the line *t m v* of *fig.* 660, that is to say, at the lowest point, *g*, *figs.* 659, 662, is pierced with a hole. Thereby the mercury which had been volatilized in *d*, if it be already condensed by the cooling in the series of aludels *f g*, may pass into the corresponding gutter, next into the hole *m*, *fig.* 660, and after that into the wooden pipes *h h'*, *fig.* 659, which conduct it across the masonry of the terrace into cisterns filled with water; see *q*, *fig.* 661, which is the plan of *fig.* 662.

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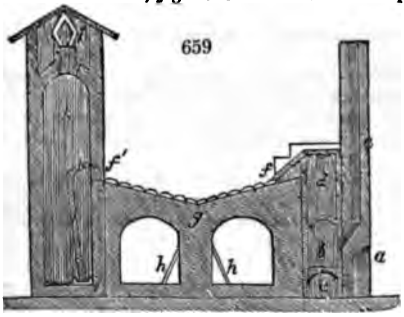

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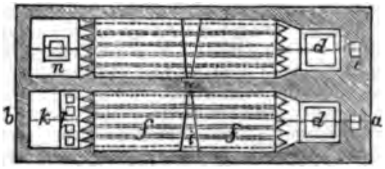

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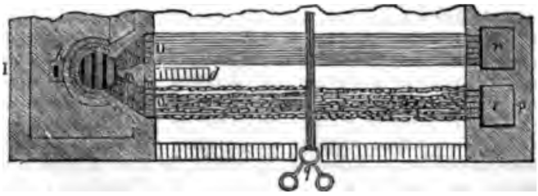

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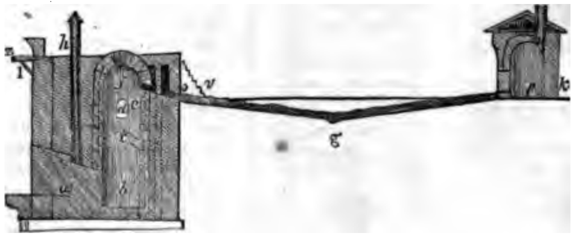

The portion of mercury not condensed in the range of aludels, *f g*, which is the most considerable, goes in the state of vapor, into a chamber *k*; but in passing under a partition *l l*, a certain portion is deposited in a cistern *i*, filled with water. The greater part of the vapors diffused in the chamber *k′* is thereby condensed, and the mercury falls down upon the two inclined planes which form its bottom. What may still exist as vapor passes into an upper chamber *k′*, by a small chimney *n*. On one of the sides of this chamber there is a shutter which may be opened at pleasure from below upwards, and beneath this shutter, there is a gutter into which a notable quantity of mercury collects. Much of it is also found condensed in the aludels. These facts prove that this process has inconveniences which have been tried to be remedied by the more extensive but rather unchemical grand apparatus of Idria.

Details of the aludel apparatus: 25 are set in each of the 12 ranges, seen in *fig.* 661, constituting 300 pear-shaped stoneware vessels, open at both ends, being merely thrust into one another, and luted with loam. What a multitude of joints, of which a great many must be continually giving way by the shrinkage of the luting, whereby the mercurial fumes will escape with great loss of product, to poison the air!

a, is the door of the fire-place; *c*, the perforated arches upon which the ore is piled in the chamber *e*, through the door *d*, and an orifice at top; the latter being closed during the distillation; *f f* are vents for conducting the mercurial vapors into two chambers *i*, separated by a triangular body of masonry *m n*; *h* is the smoke chimney of the fire-place; *o o*, are the ranges of aludels, in connexion with the chamber *i*, which are laid slantingly towards the gutter *q*, upon the double inclined plane terrace, and terminate in the chamber *h q*; this being surmounted by two chimneys *t*. The mercury is collected in these aludels and in the basins at *q* and *p*, *fig.* 661. *r* is a thin stone partition set up between the two principal walls of each of the furnaces. *v* is the stair of the aludel terrace, leading to the platform which surmounts the furnace; *z* is a gutter for conducting away the rains which may fall upon the buildings.

Great apparatus of Idria.—Before entering into details of this laboratory, it will not be useless to recapitulate the metallurgic classification of the ores treated in it. 1. the ores in large blocks, fragments, or shivers, whose size varies from a cubic foot to that of a nut. 2. The smaller ores, from the size of a nut to that of grains of dust.

The first class of *large* ores comprises three subdivisions, namely; *a*, blocks of metalliferous rocks, which is the most abundant and the poorest species of ore, affording only one *per cent.* of mercury; *b*, the massive sulphuret of mercury, the richest and rarest ore, yielding 80 *per cent.* when it is picked; *c*, the fragments or splinters proceeding from the breaking and sorting, and which vary in value, from 1 to 40 *per cent.*

The second class of small ores comprises: *d*, the fragments or shivers extracted from the mine in the state of little pieces, affording from 10 to 12 *per cent.*; *e*, the kernels of ore separated on the sieve, yielding 32 *per cent.*; *f* the sands and paste called *schlich*, obtained in the treatment of the poorest ores, by means of the stamps and washing tables; 100 parts of this *schlich* give at least 8 of quicksilver.

The general aspect of the apparatus is indicated by *figs.* 663, 664, and 665. *Fig.* 665, represents the exterior, but only one half, which is enough, as it resembles exactly the other, which is not shown. In these three figures the following objects may be distinguished; *figs.* 663, 664, *a*, door of the fire-place; *b*, the furnace in which beech-wood is burned mixed with a little fir-wood; *c*, door of the ash-pit, extended beneath; *d*, a space in which the ores are deposited upon the seven arches, 1 to 7, as indicated in *figs.* 663, and 666; *e e*, brick tunnels, by which the smoke of the fuel and the vapors of mercury pass, on the one side, into successive chambers *f k*.

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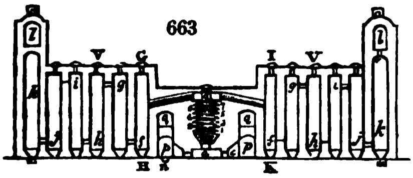

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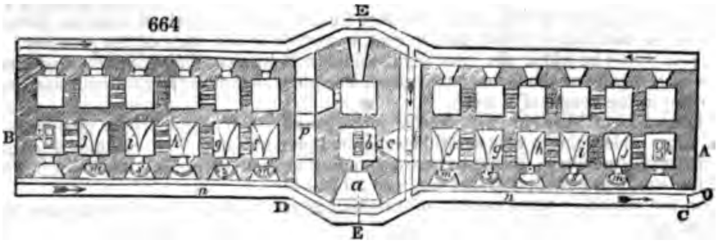

f g h i j k l are passages which permit the circulation of the vapors from the furnace *a b c d*, to the chimneys *l l*. *Figs.* 663 and 664 exhibit clearly the distribution of these openings on each side of the same furnace, and in each half of the apparatus, which is double, as *fig.* 664 shows; the spaces without letters being in every respect similar to the spaces mentioned below. *Fig.* 664 is double the scale of *fig.* 663.

m m', *fig.* 664, are basins of reception, distributed before the doors of each of the chambers *f k f' k'*. The condensed mercury which flows out of the chambers is conveyed thither. *n n'* is a trench into which the mercury, after being lifted into the basins *m*, is poured, so that it may run towards a common chamber *o*, in the sloping direction indicated by the arrows. *o* leads to the chamber where the mercury is received into a porphyry trough; out of which it is laded and packed up in portions of 50 or 100 lbs. in sheep-skins prepared with alum. *p p'*, *fig.* 663, are vaulted arches, through which a circulation may go on round the furnace *a b c d*, on the ground level. *q q'* are the vaults of the upper stories. *r r'*, *fig.* 665, vaults which permit access to the tunnels *e' e''*, *fig.* 663.

s s' and *t t'*, *fig.* 665, are the doors of the chambers *f k* and *f' k'*. These openings are shut during the distillation by wooden doors faced with iron, and luted with a mortar of clay and lime. *u u'* is the door of the vaults 1 to 7 of the furnace represented in *fig.* 663. These openings are hermetically shut, like the preceding. v v', *fig.* 663, are superior openings of the chambers, closed duing the operation by luted plugs; they are opened afterwards to facilitate the cooling of the apparatus, and to collect the mercurial soot. *x y z*, *fig.* 666, are floors which correspond to the doors *u u'* of the vaults 1 to 7, *fig.* 665. These floors are reached by stairs set up in the different parts of the building, which contains the whole apparatus.

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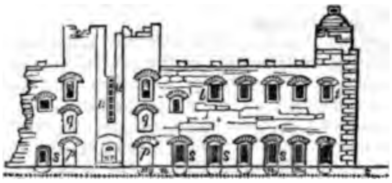

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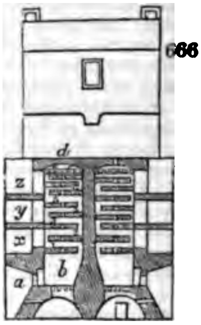

On the lower arches the largest blocks of metalliferous rock are laid; over these the less bulky fragments are arranged, which are covered with the shivers and pieces of less dimension. On the middle vaults, the small ore is placed, distributed into cylindrical pipkins of earthenware, of 10 inches diameter and 5 inches depth. The upper vaults receive likewise pipkins filled with the sands and pastes called *schlich*.

In 3 hours, by the labor of 40 men, the two double sets of apparatus are charged, and all the apertures are closed. A quick fire of beech-wood is then kindled; and when the whole mass has become sufficiently heated, the sulphuret of mercury begins to vaporize; coming into contact with the portion of oxygen which had not been carbonated, by combustion, its sulphur burns into sulphurous acid, while the mercury becomes free, passes with the other vapors into the chambers for condensing it, and precipitates in the liquid form at a greater or less distance from the fire-place. The walls of the chambers and the floors, with which their lower portion is covered, are soon coated over with a black mercurial soot, which, being treated anew, furnishes 50 *per cent.* of mercury. The distillation lasts from 10 to 12 hours; during which time the whole furnace is kept at a cherry-red heat. A complete charge for the two double apparatus, consists of from 1000 to 1300 quintals of ore, which produce from 80 to 90 quintals of running mercury. The furnace takes from 5 to 6 days to cool, according to the state of the weather; and if to that period be added the time requisite for withdrawing the residuums, and attend, ing to such repairs as the furnace may need, it is obvious that only one distillation can be performed in the course of a week.

In the works of Idria, in 1812, 56,686 quintals and a half of quicksilver ores were distilled, after undergoing a very careful mechanical preparation. They afforded 4832 quintals of running mercury; a quantity corresponding to about 8½ *per cent.* of the ore. These smelting works are about 180 feet long and 30 feet high.

Upon the preceding three systems of smelting mercurial ores, I shall now make some observations.

It has been long well known, that quicksilver may be most readily extracted from cinnabar, by heating it in contact with quicklime. The sulphur of the cinnabar combines, by virtue of a superior affinity with the lime, to the exclusion of the quicksilver, to form sulphurets of lime and calcium, both of which being fixed *hepars*, remain in the retort while the mercury is volatilized by the heat. In a few places, hammerschlag, or the iron cinder, driven off from the blooms by the tilting hammer, has been used instead of lime in the reduction of this mercurial ore, whereby sulphurous acid and sulphuret of iron are formed.

The annual production of the Bavarian Rhine provinces has been estimated at from 400 to 550 quintals; that of Almaden, in the year 1827, was 22,000 quintals; and of Idria, at present, is not more than 1500 quintals.

All the plans hitherto prescribed for distilling the ore along with quicklime, are remarkably rude. In that practised at Landsberg by Obermoschel, there is a great waste of labor, in charging the numerous small cucurbits; there is a great waste of fuel in the mode of heating them; a great waste of mercury by the imperfect luting of the retorts to the receivers, as well as the imperfect condensation of the mercurial vapors; and probably a considerable loss by pilfering.

The modes practised at Almaden and Idria are, in the greatest degree, barbarous; the ores being heated upon open arches, and the vapors attempted to be condensed by enclosing them within brick or stone and mortar walls, which can never be rendered either sufficiently tight or cool.

To obviate all these inconveniences and sources of loss, the proper chemical arrangements suited to the present improved state of the arts ought to be adopted, by which labor, fuel, and mercury, might all be economized to the utmost extent. The only apparatus fit to be employed is a series of cast-iron cylinder retorts, somewhat like those employed in the coal gas works, but with peculiarities suited to the condensation of the mercurial vapors. Into each of these retorts, supposed to be at least one foot square in area, and 7 feet long, 6 or 7 cwts. of a mixture of the ground ore with the quicklime, may be easily introduced, from a measured heap, by means of a shovel. The specific gravity of the cinnabar being more than 6 times that of water, a cubic foot of it will weigh more than 3½ cwts.; but supposing the mixture of it with quicklime (when the ore does not contain the calcareous matter itself) to be only thrice the density of water, then four cubic feet might be put into each of the above retorts, and still leave 1½ cubic feet of empty space for the expansion of volume which may take place in the decomposition. The ore should certainly be ground to a moderately fine powder, by stamps, iron cylinders, or an edge wheel, so that when mixed with quicklime, the cinnabar may be brought into intimate contact with its decomposer, otherwise much of it will be dissipated unproductively in fumes, for it is extremely volatile.

Figs. 667, 668, 669, represent a cheap and powerful apparatus which I contrived at the request of the German Mines Company of London, and which is now mounted at Landsberg, near Obermoschel, in the Bavarian Rhein-Kreis.

Fig. 667, is a section parallel to the front elevation of three arched benches of retorts, of the size above specified. Each bench contains 3 retorts, of the form represented by *a a a*. I, is the single fire-place or furnace, capable of giving adequate ignition by coal or wood, to the three retorts. The retorts were built up in an excellent manner, by an English mason perfectly acquainted with the best modes of erecting coal-gas retorts, who was sent over on purpose. The path of the flame and smoke is precisely similar to that represented in *fig.* 483, page 555, whereby the uppermost retort is immersed in a bath of uniformly ignited air, while the currents reverberated from the top, play round the two undermost retorts, in their way to the vent-flues beneath

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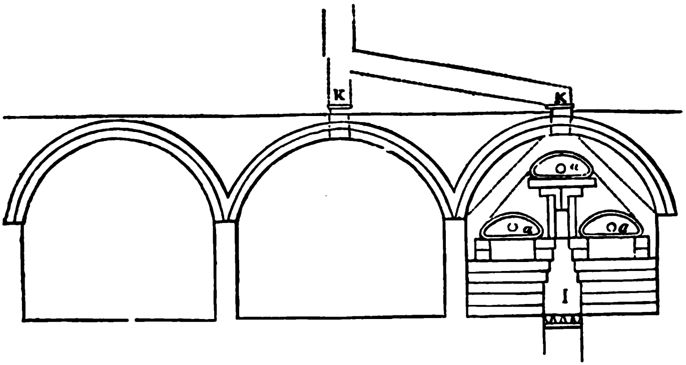

them. The bottom of the uppermost retort is protected from the direct impulse of the flame by fire-tiles. The dotted lines K K, show the paths of the chimneys which rise at the back ends of the retorts.

In the section, *fig.* 668, *a* is the body of the retort; its mouth at the right hand end is shut, as usual, by a luted iron lid, secured with a cross-bar and screw-bolts; its other end is prolonged by a sloping pipe of cast iron, 4 inches in diameter, furnished with a nozzle hole at L, closed with a screw plug. Through this hole a wire rammer may be introduced, to ascertain that the tube is pervious, and to cleanse it from the mercurial soot, when thought necessary. *c*, is a cross section of the main condenser, shown in a longitudinal section at C C, *fig.* 669. This pipe is 18 inches in diameter, and about 20 feet long. At *a a*, &c., the back ends of the retorts are seen, with the slanting tubes *b b*, &c., descending through orifices in the upper surface of the condenser pipe, and dipping their ends just below the water-line *h i*. *g*, is the cap of a water valve, which removes all risk from sudden expansion or condensation. The condenser is placed within a rectangular trough, made either of wood or stone, through which a sufficient stream of water passes to keep it perfectly cool, and repress every trace of mercurial vapor, and it is laid with a slight inclination from *i* to *h*, so that the condensed quicksilver may spontaneously flow along its bottom, and pass through the vertical tube D into the locked up iron chest, or magazine *e*. This tube D is from the beginning closed at bottom, by immersion in a shallow iron cup, always filled with mercury. *k* is a graduated gauge rod, to indicate the progressive accumulation of quicksilver in the chest, without being under the necessity of unlocking it.

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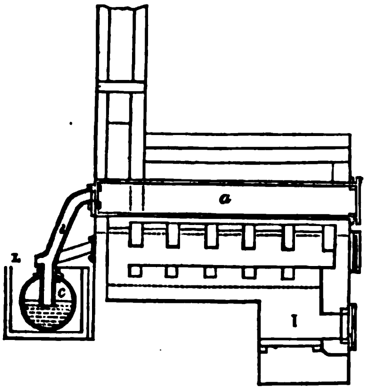

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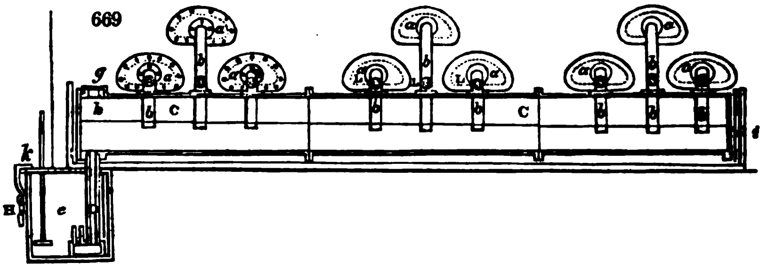


This air-tight apparatus was erected about a year ago, and has been found to act perfectly well; I regret, however, that my professional engagements at home have not hitherto permitted me to conduct its operations personally for some days. The average samples of cinnabar ore from Obermoschel are ten times poorer than those of Almaden. Were such an apparatus as the above, with some slight modifications which have lately occurred to me, mounted for the Spanish mines, I am confident that their produce in quicksilver might be nearly doubled, with a vast economy of fuel, labor, and human life. The whole cost of the 9 large retorts, with their condensing apparatus, iron magazine, &c., was very little more than *two hundred pounds!* As the retorts are kept in a state of nearly uniform ignition, like those of the gas works, neither they nor the furnaces are liable to be injured in their joints by the alternate contractions and expansions, which they would inevitably suffer if allowed to cool; and being always ready heated to the proper pitch for decomposing the mercurial ores, they are capable of working off a charge, under skilful management, in the course of 3 hours. Thus, in 24 hours, with a relay of laborers, 8 charges of at least 5 cwts. of ore each, might be smelted=2 tons, with 3 retorts, and 6 tons with 9 retorts; with a daily product from the rich ores of Almaden, or even Idria, of from 12 cwts. to 20 cwts. Instead of 3 benches of 3 retorts each, I would recommend 15 benches, containing 45 retorts, to be erected for either the Almaden or Idria mines; which, while they would smelt all their ores, could be got for a sum not much exceeding 1000*l*., an outlay which they would reimburse within a month or two.

Quicksilver is a substance of paramount value to science. Its great density and its *regular rate of expansion* and contraction by increase and diminution of temperature, give it the preference over all liquids for filling barometric and thermometric tubes. In chemistry it furnishes the only means of collecting and manipulating, in the pneumatic trough, such gaseous bodies as are condensable over water. To its aid, in this respect, the modern advancement of chemical discovery is pre-eminently due.

This metal alloyed with tin-foil forms the reflecting surface of looking glasses, and by its ready solution of gold or silver, and subsequent dissipation by a moderate heat, it becomes the great instrument of the arts of gilding and silvering copper and brass. The same property makes it so available in extracting these precious metals from their ores. The anatomist applies it elegantly to distend and display the minuter vessels of the lymphatic system, and secretory systems, by injecting it with a syringe through all their convolutions. It is the basis of many very powerful medicines, at present probably too indiscriminately used, to the great detriment of English society; for it is far more sparingly prescribed by practitioners upon the continent of Europe, not otherwise superior in skill or science to those of Great Britain.

The nitrate of mercury is employed for the *secretage* of rabbit and hare-skins, that is, for communicating to the fur of these and other quadrupeds the faculty of felting, which they do not naturally possess. With this view the solution of that salt is applied to them lightly in one direction with a sponge. A compound amalgam of zinc and tin is probably the best exciter which can be applied to the cushions of electrical machines. Mercury imported for home consumption in 1836, 286,808 lbs.; in 1837, 314,036 lbs.

The only mercurial compounds which are extensively used in the arts, are factitious cinnabar or VERMILION, and corrosive sublimate.

MERCURY, BICHLORIDE OF; *Corrosive sublimate* (*Deutochlorure de mercure*, Fr.; *Aetzendes quecksilber sublimat*, Germ.), is made by subliming a mixture of equal parts of persulphate of mercury, prepared as above described, and sea-salt, in a stoneware cucurbit. The sublimate rises in vapor, and incrusts the globular glass capital with a white mass of small prismatic needles. Its specific gravity is 5·14. Its taste is acrid, stypto-metallic, and exceedingly unpleasant. It is soluble in 20 parts of water, at the ordinary temperature, and in its own weight of boiling water. It dissolves in 2½ times its weight of cold alcohol. It is a very deadly poison. Raw white of egg swallowed in profusion, is the best antidote. A solution of corrosive sublimate has been long employed for preserving soft anatomical preparations. By this means the corpse of Colonel Morland was embalmed in order to be brought from the seat of war to Paris. His features remained unaltered, only his skin was brown, and his body was so hard as to sound like a piece of wood when struck with a hammer.

In the valuable work upon the dry rot, published by Mr. Knowles, secretary of the committee of inspectors of the navy, in 1821, corrosive sublimate is enumerated among the chemical substances which had been prescribed for preventing the dry rot in timber; and it is well known that Sir H. Davy had, several years before that date, used and recommended to the Admiralty and Navy Board, corrosive sublimate as an anti-dry rot application. It has been since extensively employed by a joint-stock company for the same purpose, under the title of Kyan's patent.

MERCURY, PROTOCHLORIDE OF; *Calomel*; (*Protochlorure de mercure*, Fr.; *Versüsstes quecksilber*, Germ.) This compound, so much used and abused by medical practitioners, is commonly prepared by triturating four parts of corrosive sublimate along with three parts of running quicksilver in a marble mortar, till the metallic globules entirely disappear, with the production of a black powder, which is to be put into a glass balloon, and exposed to a subliming heat in a sand bath. The calomel, which rises in vapor, and attaches itself in a crystalline crust to the upper hemisphere of the balloon, is to be detached, reduced to a fine powder, or levigated and elutriated. 200 lbs. of mercury yield 236 of calomel and 272 of corrosive sublimate.

The following more economical process is that adopted at the Apothecaries' Hall, London. 140 pounds of concentrated sulphuric acid are boiled in a cast iron pot upon 100 pounds of mercury, till a dry persulphate is obtained. Of this salt, 124 pounds are triturated with 81 pounds of mercury, till the globules disappear, and till a protosulphate be formed. This is to be intimately mixed with 68 pounds of sea-salt, and the mixture, being put into a large stone-ware cucurbit, is to be submitted to a subliming heat. See CALOMEL.

From 190 to 200 pounds of calomel rise in a crystalline cake, as in the former process, into the capital; while sulphate of soda remains at the bottom of the alembic. The calomel must be ground to an impalpable powder, and elutriated. The vapors, instead of being condensed into a cake within the top of the globe or in a capital, may be allowed to diffuse themselves into a close vessel, containing water in a state of ebullition, whereby the calomel is obtained at once in the form of a washed impalpable powder. Calomel is tasteless and insoluble in water. Its specific gravity is 7·176.

For the compound of mercury with fulminic acid, see FULMINATE. *Periodide of mercury* is a bright but fugitive red pigment. It is easily prepared by dropping a solution of iodide of potassium into a solution of corrosive sublimate, as long as any precipitation takes place, decanting off the supernatant muriate of potash, washing and drying the precipitate.

METALLURGY (*Erzkunde*, Germ.) is the art of extracting metals from their ores. This art, which supplies industry with the instruments most essential to its wants, is alike dependant upon the sciences of chemistry and mechanics; upon the former, as directing the smelting processes, best adapted to disentangle each metal from its mineralizer; upon the latter, as furnishing the means of grinding the ores, and separating the light stony parts from the rich metallic matter.

Notwithstanding the striking analogy which exists between common chemical and metallurgic operations, since both are employed to insulate certain bodies from others, there are essential differences which should be carefully noted. In the first place, the quantity of materials being always very great in metallurgy, requires corresponding adaptations of apparatus, and often produces peculiar phenomena; in the second place, the agents to be employed for treating great masses, must be selected with a view to economy, as well as to chemical action. In analytical chemistry, the main object being exactness of result, and purity of product, little attention is bestowed upon the value of the reagents, on account of the small quantity required for any particular process. But in smelting metals upon the great scale, profit being the sole object, cheap materials and easy operations alone are admissible.

The metallic ores as presented by nature, are almost always mixed with a considerable number of foreign substances; and could not therefore be advantageously submitted to metallurgic operations, till they are purified and concentrated to a certain degree by various methods.

OF THE PREPARATION OF ORES FOR THE SMELTING HOUSE.

There are two kinds of *preparation;* the one termed mechanical, from the means employed, and the results obtained, consists in processes for breaking and grinding the ores, and for washing them so as to separate the vein-stones, gangues, or other mixed earthy matters, in order to insulate or concentrate the metallic parts.

Another kind of preparation, called chemical, has for its object to separate, by means of fire, various volatile substances combined in the ores, and which it is requisite to clear away, at least in a certain degree, before trying to extract the metals they may contain.

Lastly, an indispensable operation in several circumstances, is to discover, by simple and cheap methods, called *assays*, the quantity of metal contained in the different species of ores to be treated.

This head of our subject, therefore, falls under three subdivisions:—

§ 1. The mechanical preparation of ores, including *picking*, *stamping*, and different modes of washing.

§ 2. The chemical preparation, consisting especially in the roasting or calcination of the ores.

§ 3. The assay of ores, comprehending the mechanical part: that is, by washing; the chemical part, or assays by the *dry way;* and the assays by the *moist way.*

Section 1. *Of the mechanical preparation or dressing of ores.*—I. The first picking or sorting takes place in the interior, or underground workings, and consists in separating the fragments of rocks, that apparently contain no metallic matter, from those that contain more or less of it. The external aspect guides this separation; as also the feeling of density in the hand.

The substances, when turned out to the day, undergo another *sorting*, with greater or less care, according to the value of the included metal. This operation consists in breaking the lumps of ore with the hammer, into fragments of greater or less size, usually as large as the fist, whereby all the pieces may be picked out and thrown away that contain no metal, and even such as contain too little to be smelted with advantage. There is, for the most part, a building erected near the output of the mine, in which the breaking and picking of the ores are performed. In a covered gallery, or under a shed, banks of earth are thrown up, and divided into separate beds, on each of which a thick plate of cast iron is laid. On this plate, elderly workmen, women, and children, break the ores with hand hammers, then pick and sort them piece by piece. The matters so treated, are usually separated into three parts; 1. the rock or sterile gangue, which is thrown away; 2. the ore for the stamping mill, which presents too intimate a mixture of rock and metallic substance to admit of separation by breaking and picking; and 3. the pure ore, or at least the very rich portion, called the *sorted mine* or the *fat ore.* On the sorting floors there remains much small rubbish, which might form a fourth subdivision of ore, since it is treated in a peculiar manner, by sifting, as will be presently mentioned.

The distribution of fragments more or less rich, in one class or another, is relative to the value of the included metal, taking into account the expenses necessary for its extraction.

Thus in certain lead mines, pieces of the gangues are thrown away, which judged by the eye may contain 3 per cent. of galena, because it is known that the greater portion of this would be lost in the washings required for separating the 97 parts of the gangue, and that the remainder would not pay the expenses.

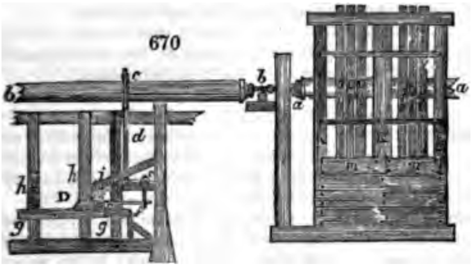
II. The very simple operations of *picking* are common to almost all ores; but there are other operations requiring more skill, care, and expense, which are employed in their final state of perfection only upon ores of metals possessing a certain value, as those of lead, silver, &c. We allude to the *washing* of ores.

The most simple and economical washings are those that certain iron ores, particularly the alluvial, are subjected to, as they are found near the surface of the ground agglutinated in great or little pieces. It is often useful to clean these pieces, in order to pick out the earthy lumps, which would be altogether injurious in the furnaces.

This crude washing is performed sometimes by men stirring in the midst of a stream of water, with iron rakes or shovels, the lumps of ore placed in large chests, or basins of wood or iron.

In other situations, this washing is executed more economically by a machine called a *buddle* or dolly-tub by our miners. A trough of wood or iron, with a concave bottom, is filled with the ore to be washed. Within the tub or trough, arms or iron handles are moved round about, being attached to the arbor of a hydraulic wheel. The trough is kept always full of water, which as it is renewed carries off the earthy matters, diffused through it by the motion of the machine, and the friction among the pieces of the ore. When the washing is finished, a door in one of the sides of the trough is opened, and the current removes the ore into a more spacious basin, where it is subjected to a kind of picking. It is frequently indeed passed through sieves in different modes. See LEAD and TIN, for figures of *buddles* and *dollies*.

III. *Stamping*. Before describing the refined methods of washing the more valuable ores of copper, silver, lead, &c., it is proper to point out the means of reducing them into a powder of greater or less fineness, by *stamping*, so called from the name *stamps* of the pestles employed for that purpose. Its usefulness is not restricted to preparing the ores; for it is employed in almost every smelting house for pounding clays, charcoal, scoriæ, &c. A stamping mill or pounding machine, *fig.* 670, consists of several moveable pillars of wood *l l l*, placed vertically, and supported in this position between frames of carpentry K K K. These pieces are each armed at their under end with a mass of iron *m*. An arbor or axle *a a*, moved by water, and turning horizontally, tosses up these wooden pestles, by means of wipers or cams, which lay hold of the shoulders of the pestles at *l l l*. These are raised in succession, and fall into an oblong trough below *m m*, scooped out in the ground, having its bottom covered either with plates of iron or hard stones. In this trough, beneath these pestles, the ore to be stamped is allowed to fall from a hopper above, which is kept constantly full.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The trough is closed in at the sides by two partitions, and includes three or four pestles; which the French miners call a battery. They are so disposed that their ascent and descent take place at equal intervals of time.

Usually a stamping machine is composed of several batteries (two, three, or four), and the arrangement of the wipers on the arbor of the hydraulic wheel is such that there is constantly a like number of pestles lifted at a time; a circumstance important for maintaining the uniform going of the machine.

The matters that are not to be exposed to subsequent washing are stamped dry, that is, without leading water into the trough; and the same thing is sometimes done with the rich ores, whose lighter parts might otherwise be lost.

Most usually, especially for ores of lead, silver, copper, &c., the trough of the stamper is placed in the middle of a current of water, of greater or less force; which, sweeping off the pounded substances, deposites them at a greater or less distance onwards, in the order of the size and richness of the grain; constituting a first washing, as they escape from beneath the pestles.

In the dry stamping, the fineness of the powder depends on the weight of the pestles, the height of their fall, and the period of their action upon the ore; but in the stampers exposed to a stream of water, the retention of the matters in the trough is longer or shorter, according to the facility given for their escape. Sometimes these matters flow out of the chest over its edges, and the height of the line they must surmount has an influence on the size of the grain; at other times, the water and the pounded matter which it carries off, are made to pass through a grating, causing a kind of sifting at the same time. There are, however, some differences in the results of these two methods. Lastly, the quantity of water that traverses the trough, as well as its velocity, has an influence on the discharge of the pounded matters, and consequently on the products of the stampers.

The size of the particles of the pounded ore being different, according to the variable hardness of the matters which compose them, suggests the means of classing them, and distributing them nearly in the order of their size and specific gravity, by making the water, as it escapes from the stamping trough, circulate in a system of canals called a *labyrinth*, where it deposites successively, in proportion as it loses its velocity, the earthy and metallic matters it had floated along. These metalliferous portions, especially when they have a great specific gravity like galena, would be deposited in the first passages, were it not that from their hardness being inferior to that of the *gangue*, they are reduced to a much finer powder, or into thin plates, which seem to adhere to both the watery and earthy particles; whence they have to be sought for among the finest portions of the pulverized gangue, called slime, *schlich*, or *schlamme*.

There are several methods of conducting the stamps; in reference to the size of the grains wished to be obtained, and which is previously determined agreeably to the nature of the ore, and of the gangue; its richness, &c. The height of the slit that lets the pounded matters escape, or the diameters of the holes in the grating, their distance, the quantity of water flowing in, its velocity, &c., modify the result of the stamping operation.

When it is requisite to obtain powder of an extreme fineness, as for ores that are to be subjected to the process of amalgamation, they are passed under millstones, as in common corn mills; and after grinding, they are bolted so as to form a species of flour; or they are crushed between rolls. See Lead and Tin.

Washing of ores.

IV. The ores pounded under the stamps are next exposed to very delicate operations, both tedious and costly, which are called the *washings*. Their purpose is to separate mechanically the earthy matters from the metallic portion, which must therefore have a much higher specific gravity; for otherwise, the washing would be impracticable.

The medium employed to diminish the difference of specific gravity, and to move along the lightest matters, is water; which is made to flow with greater or less velocity and abundance over the schlich or pasty mud spread on a table of various inclination.

But as this operation always occasions, not only considerable expense, but a certain loss of metal, it is right to calculate what is the degree of richness below which washing is unprofitable; and on the other hand, what is the degree of purification of the *schlich* at which it is proper to stop, because too much metal would be lost comparatively with the expense of fusing a small additional quantity of gangue. There cannot, indeed, be any fixed rule in this respect, since the elements of these calculations vary for every work.

Before describing the different modes of washing, we must treat of the sifting or riddling, whose purpose, like that of the labyrinth succeeding the stamps, is to distribute and to separate the ores (which have not passed through the water stamps) in the order of the coarseness of grain. This operation is practised particularly upon the debris of the mine, and the rubbish produced in breaking the ores. These substances are put into a riddle, or species of round or square sieve, whose bottom is formed of a grating instead of a plate of metal pierced with holes. This riddle is plunged suddenly and repeatedly into a tub or cistern filled with water. This liquid enters through the bottom, raises up the mineral particles, separates them and keeps them suspended for an instant, after which they fall down in nearly the order of their specific gravities, and are thus classed with a certain degree of regularity. The sieve is sometimes dipped by the immediate effort of the washer; sometimes it is suspended to a swing which the workman moves; in order that the riddling may be rightly done, the sieve should receive but a single movement from below upwards; in this case the ore is separated from the gangue, and if there be different specific gravities, there are formed in the sieve as many distinct strata, which the workman can easily take out with a *spatula*, throwing the upper part away when it is too poor to be re-sifted. This operation by the hand-sieve, is called *riddling in the tub*, or riddling by deposite.

We may observe, that during the sifting, the particles which can pass across the holes of the bottom, fall into the tub and settle down there; whence they are afterwards gathered out, and exposed to washing when they are worth the trouble.

Sometimes, as at Poullàouen, the sieves are conical, and held by means of two handles by a workman; and instead of receiving a single movement, as in the preceding method, the sifter himself gives them a variety of dexterous movements in succession. His object is to separate the poor portions of the ore from the richer; in order to subject the former to the stamp mill.

Among the siftings and washings which ores are made to undergo, we must notice a among the most useful and ingenious, those practised by *iron gratings*, called on the Continent *grilles anglaises*, and the *step-washings* of Hungary, *laveries à gradins*. These methods of freeing the ores from the pulverulent earthy matters, consist in placing them, at their out-put from the mine, upon gratings, and bringing over them a stream of water, which merely takes down through the bars the small fragments, but carries off the pulverulent portions. The latter are received in cisterns, where they are allowed to rest long enough to settle to the bottom. The washing by steps is an extension of the preceding plan. To form an idea, let us imagine a series of grates placed successively at different levels, so that the water, arriving on the highest, where the ore for washing lies, carries off a portion of it, through this first grate upon a second closer in its bars, thence to a third, &c., and finally into labyrinths or cisterns of deposition.

The *grilles anglaises* are similar to the *sleeping tables* used at Idria. The system of these *en gradins* is represented in *fig*. 671. There are 5 such systems in the works at Idria, for

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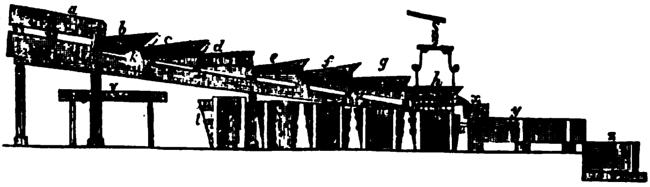

the sorting of the small morsels of quicksilver ore, intended for the stamping mill. These fragments are but moderately rich in metal, and are picked up at random, of various sizes, from that of the fist to a grain of dust.

These ores are placed in the chest *a*, below the level of which 7 grates are distributed, so that the fragments which pass through the first *b*, proceed by an inclined conduit on to the second grate *c*, and so in succession. (See the conduits *l*, *o*, *p*). In front, and on a level with each of the grates *b*, *c*, *d*, &c., a child is stationed on one of the floors, 1, 2 3, to 7.

A current of water, which falls into the chest *a*, carries the fragments of ore upon the grates. The pieces which remain upon the two grates *b* and *c*, are thrown on the adjoining table *v*, where they undergo a sorting by hand; there the pieces are classified, 1. into gangue to be thrown away; 2. into ore for the stamp mill; 3. into ore to be sent directly to the furnace. The pieces which remain on each of the succeeding grates, *d*, *e*, *f*, *g*, *h*, are deposited on those of the floors 3 to 7, in front of each. Before every one of these shelves a deposite-sieve is established, (see *t*; *u*,) and the workmen in charge of it stand in one of the corresponding boxes, marked 8 to 12. The sieve is represented only in front of the chest *h*, for the sake of clearness.

Each of the workmen placed in 8, 9, 10, 11, 12, operates on the heap before him; the upper layer of the deposite formed in his sieve, is sent to the stamping house, and the inferior layer directly to the furnace.

As to the grains which, after traversing the five grates, have arrived at the chest *x*, they are washed in the two chests *y*, which are analogous to the German chests to be presently described. The upper layer of what is deposited in *y* is sent to the furnace; the rest is treated anew on three tables of percussion, similar to the English brake-sieves, also to be presently described.

After several successive manipulations on these tables, an upper stratum of *schlich* is obtained fit for the furnace; an intermediate stratum, which is washed anew by the same process; and an inferior stratum, that is sent to the system of stamps, *fig*. 672.

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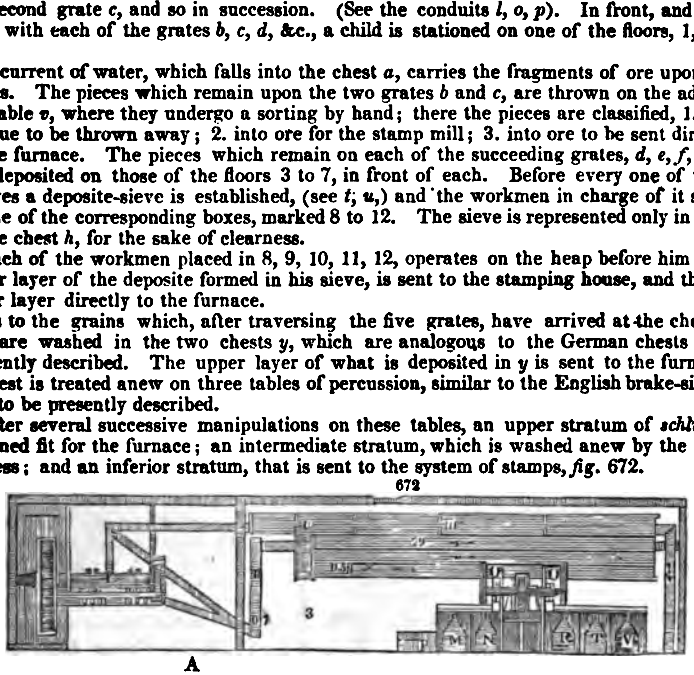


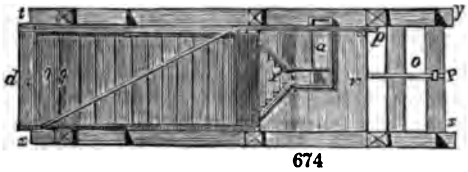
This figure represents the general ground plan of a stamping and washing mill. The stamps r are composed of two batteries similar to *fig*. 670. The ore passes in succession under three pestles of cast iron, each of which is heavier the nearer it is to the sieve through which the *sand* or pounded matter escapes.

In the upper part of the figure we see issuing from the stamps, two conduits destined to receive the water and the metalliferous sand with which it is loaded. The first, marked r, s, w, is used only when a certain quality of ore is *stamped*, richer in metal than is usually treated by means of the second conduit, the first being closed. The second conduit, or that employed for ordinary manipulation when the other is shut, is indicated by F, 0·7, B; then by 0·58 and 0·29. These numbers express the depth of the corresponding portions of this conduit. From F to B, the conduit or water-course is divided into three portions much shallower, called the *rich conduit*, the *middle conduit*, and the *inferior*. Beyond the basin B, the conduit takes the name of labyrinth. There the muddy sediments of ore are deposited; being the finer the further they are from the stamps F. Darts indicate the direction of the stream in the labyrinth. On the *German chests*, placed at 3, the sand derived from the rich and middle conduits is treated, in order to obtain three distinct qualities of *schlich*, as already mentioned. P is a cloth-covered table, for treating the deposite of the German chests at 3. M N are two sweep tables (*à balai*), for treating the ore collected in the lower conduit, which precedes the midmost of the three German chests. Upon the three similar tables R T V, are treated in like manner the muddy deposites of the labyrinth, which forms suite to three parallel German chests situated at 3, not shown for want of room in the figure, but connected in three rectangular zigzags with each other, as well as by a transverse branch to the points 0·7 and P. At the upper part of these five sweep tables, the materials which are to undergo washing are agitated in two boxes O O, by small paddle-wheels.

We shall now describe the *percussion-tables* used in the Hartz, for treating the sand of ore obtained from the conduits represented above.

Figs. 673, 674, and 675, exhibit a plan, a vertical section, and elevation, of one of these tables, taken in the direction of its length. The *arbor* or great shaft in prolongation from the stamps mill, is shown in section perpendicularly to its axis, at A. The *cams* or wipers are shown round its circumference, one of them having just acted on *n*.

673



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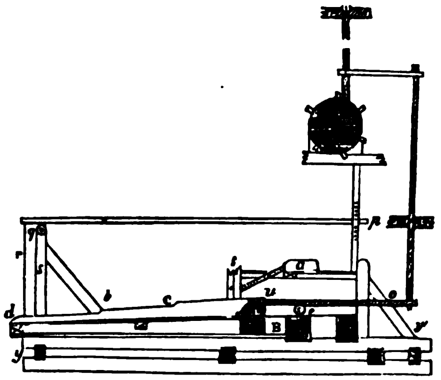

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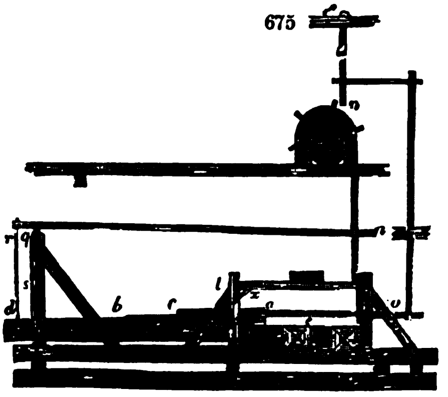

These cams, by the revolution of the arbor, cause the alternating movements of a horizontal bar of wood *o*, *u*, which strikes at the point *u* against a table *d*, *b*, *c*, *u*. This table is suspended by two chains *t*, at its superior end, and by two rods at its lower end. After having been pushed by the piece *o*, *u*, it rebounds to strike against a block or bracket B. A lever *p*, *q*, serves to adjust the inclination of the moveable table, the pivots *q* being points of suspension.

The ore-sand to be washed, is placed in the chest *a*, into which a current of water runs. The ore floated onwards by the water, is carried through a sieve on a sloping small table *x*, under which is concealed the higher end of the moveable table *d*, *b*, *c*, *u*; and it thence falls on this table, diffusing itself uniformly over its surface. The particles deposited on this table form an oblong *talus* (slope) upon it; the successive percussions that it receives, determine the weightier matters, and consequently those richest in metal, to accumulate towards its upper end at *u*. Now the workman by means of the lever *p*, raises the lower end *d* a little in order to preserve the same degree of inclination to the surface on which the deposite is strewed. According as the substances are swept along by the water, he is careful to remove them from the middle of the table towards the top, by means of a wooden roller. With this intent, he walks on the table *d b c u*, where the sandy sediment has sufficient consistence to bear him. When the table is abundantly charged with the washed ore, the deposite is divided into three bands or segments *d b*, *b c*, *c u*. Each of these bands is removed separately and thrown into the particular heap assigned to it. Every one of the heaps thus formed becomes afterwards the object of a separate manipulation on a percussion table, but always according to the same procedure. It is sufficient in general to pass twice over this table the matters contained in the heap, proceeding from the superior band *c u*, in order to obtain a pure *schlich*; but the heap proceeding from the intermediate belt *b c*, requires always a greater number of manipulations, and the lower band *d b* still more. These successive manipulations are so associated that eventually each heap furnishes pure *schlich*, which is obtained from the superior band *c u*. As to the lightest particles which the water sweeps away beyond the lower end of the percussion table, they fall into conduits; whence they are lifted to undergo a new manipulation.

Fig. 676 is a profile of a plan which has been advantageously substituted, in the Hartz, for that part of the preceding apparatus which causes the jolt of the piece *o u* against the table *d b c u*. By means of this plan, it is easy to vary, according to the circumstances of a manipulation always delicate, the force of percussion which a bar *x y*, ought to communicate by its extremity *y*. With this view, a slender piece of wood *u* is made to slide in an upright piece, *v x*, adjusted upon an axis at *v*. To the piece *u* a rod of iron is connected, by means of a hinge *z*; this rod is capable of entering more or less into a case or sheath in the middle of the piece *v x*, and of being stopped at the proper point, by a thumb-screw which presses against this piece. If it be wished to increase the force of percussion, we must lower the point *z*; if to diminish it, we must raise it. In the first case, the extremity of the piece *u*, advances so much further under the cam of the driving shaft *t*; in the second, it goes so much less forwards; whereby the adjustment is produced.

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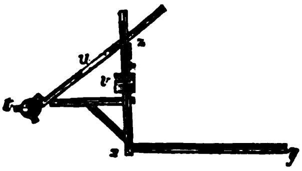

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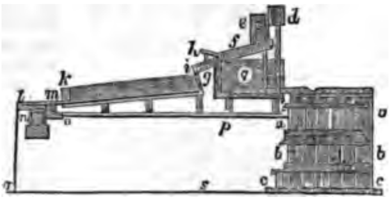

Figs. 677 and 678 represent a complete system of *sleeping tables*, *tables dormantes*: such as are mounted in Idria. *Fig.* 678 is the plan, and *fig.* 677 a vertical section. The mercurial ores, reduced to a sand by stamps like those of *fig.* 672, pass into a series of conduits *a a*, *b b*, *c c*, which form three successive floors below the level of the floor of the works. The sand taken out of these conduits is thrown into the cells *q*; whence they are transferred into the trough *e*, and water is run upon them by turning two stopcocks for each trough. The sand thus diffused upon each table, runs off with the water by a groove *f*, comes upon a sieve *h*, spreads itself upon the board *g*, and thence falls into the slanting chest, or sleeping table *i k*. The under surface *k* of this chest is pierced with holes, which may be stopped at pleasure with wooden plugs. There is a conduit *m*, at the lower end of each table, to catch the light particles carried off by the water out of the chest *i k*, through the holes properly opened, while the denser parts are deposited upon the bottom of this chest. A general conduit *n* passes across at the foot of all the chests *i k*; it receives the refuse of the washing operations.

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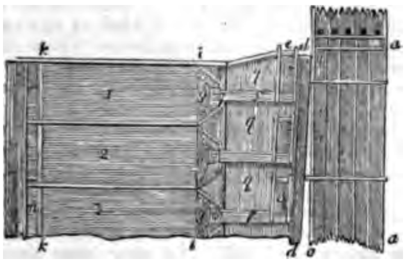

Fig. 679 is a set of stamping and washing works for the ores of argentiferous galena, as mounted at *Bockwiese*, in the district of Zellerfeldt, in the Hartz.

A is the stamp mill and its subsidiary parts; among which are *a*, the driving o main shaft; *b*, the overshot water-wheel; *c c*, six strong rings or hoops of cast iron, for receiving each a cam or tappet; *g*, the brake of the machine; *k*, *k*, *k*, the three standards of the stamps; *l l*, &c. six pestles of pine wood, shod with lumps of cast iron. There are two chests, out of which the ore to be ground falls spontaneously into the two troughs of the stamps. Of late years, however, the ore is mostly supplied by hand; the water-course terminates a short distance above the middle of the wheel *b*. There is a stream of water for the service of the stamps, and conduits proceeding from it, to lead the water into the two stamp troughs; the conduit of discharge is common to the two batteries or sets of stamps through which the water carries off the sand or stamped ore. There is a moveable table of separation, mounted with two sieves. The sands pass immediately into the conduit placed upon a level with the floor, and separated into two compartments, the first of which empties its water into the second. There are two boards of separation, or tables, laid upon the ground, with a very slight slope of only 15 inches from their top to their bottom. Each of these boards is divided into four cases with edges; the whole being arranged so that it is possible, by means of a flood-gate or sluice, to cause the superfluous water of the case to pass into the following ones. Thus the work can go on without interruption, and alternately upon the two boards. There are winding canals in the labyrinth, N, N, N, in which are deposited the particles carried along by the water which has passed upon the boards. The depth of these canals gradually increases from 12 to 20 inches, to give a suitable descent for maintaining the water-flow. At D, two percussion tables are placed. F G are two German chests. H J are two percussion tables, which are driven by the cams *z z*, fixed upon the main shaft *x y*. K K′ are two sloping sweep tables (*à balai*).

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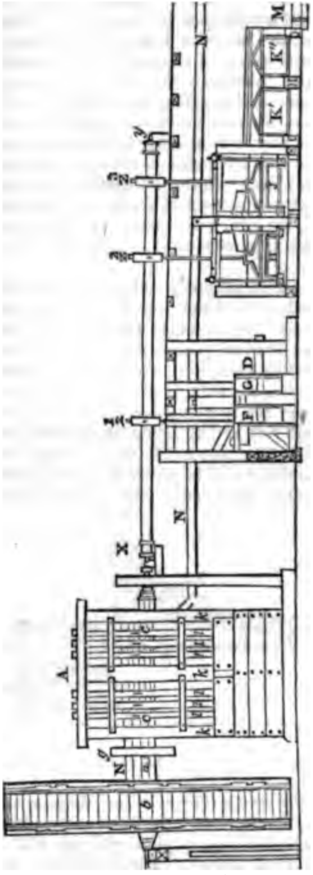

The *German chests* are rectangular, being about 3 yards long, half a yard broad, with edges half a yard high; and their inclination is such that the lower end is about 15 inches beneath the level of the upper. At their upper end, usually called the bolster, a kind of trough or box, without any edge at the side next the chest, is placed, containing the ore to be washed. The water is allowed to fall upon the bolster in a thin sheet.

The *sleeping tables* have upright edges; they are from 4 to 5 yards long, nearly 2 yards wide, and have fully a yard of inclination.

The preceding tables are sometimes covered with cloth, particularly in treating ores that contain gold, on a supposition that the woollen or linen fibres would retain more surely the metallic particles; but this method appears on trial to merit no confidence, for it produces a very impure *schlich*.

Fig. 680 is a swing-sieve employed in the Hartz, for sifting the small fragments of the ore of argentiferous lead. Such an apparatus is usually set up in the outside of a stamp and washing mill; its place being denoted by the letter A, in *fig.* 672. The two moveable chests or boxes A B, of the sieve, are connected together, at their lower ends, with an upright rod, which terminates at one of the arms of a small balance beam, mounted between the driving shaft of the stamps and the sieve, perpendicularly to the length of both. The opposite arm of this beam carries another upright rod, which ears (cams or *mentonnets*), placed on purpose upon the driving shaft, may push down. During this movement the two lower ends A, B, are raised; and when the peg-cam of the shaft quits the rod which it had depressed, the swing chests fall by their own weight. Thus they

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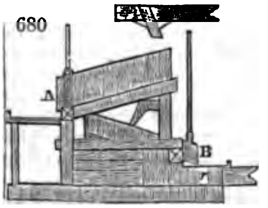

are made to vibrate alternately upon their axes. The small ore is put into the upper part of the chest A, over which a stream of water falls from an adjoining conduit. The fragments which cannot pass through a cast iron grid in the bottom of that chest, are sorted by hand upon a table in front of A, and they are classed by the workman, either among the ores to be stamped, whether dry or wet, or among the rubbish to be thrown away, or among the copper ores to be smelted by themselves. As to the small particles which fall through the grid upon the chest B, supplied also with a stream of water, they descend successively upon two other brass wire sieves, and also through the iron wire *r*, in the bottom of B.

In certain mines of the Hartz, tables called *à balais*, or *sweeping tables*, are employed. The whole of the process consists in letting flow, over the sloping table, in successive currents, water charged with the ore, which is deposited at a less or greater distance, as also pure water for the purpose of washing the deposited ore, afterwards carried off by means of this sweeping operation.

At the upper end of these *sweep-tables*, the matters for washing are agitated in a chest, by a small wheel with vanes, or flap-boards. The conduit of the muddy waters opens above a little table or shelf; the conduit of pure water, which adjoins the preceding, opens below it. At the lower part of each of these tables, there is a transverse slit, covered by a small door with hinges, opening outwardly, by falling back towards the foot of the table. The water spreading over the table, may at pleasure be let into this slit, by raising a bit of leather which is nailed to the table, so as to cover the small door when it is in the shut position; but when this is opened, the piece of leather then hangs down into it. Otherwise the water may be allowed to pass freely above the leather, when the door is shut. The same thing may be done with a similar opening placed above the conduit. By means of these two slits, two distinct qualities of *schlich* may be obtained, which are deposited into two distinct conduits or canals. The refuse of the operation is turned into another conduit, and afterwards into ulterior reservoirs, whence it is lifted out to undergo a new washing.

In the percussion tables, the water for washing the ores is sometimes spread in slender streamlets, sometimes in a full body, so as to let two cubic feet escape per minute. The number of shocks communicated per minute, varies from 15 to 36; and the table may be pushed out of its settled position at one time, three quarters of an inch, at another nearly 8 inches. The coarse ore-sand requires in general less water, and less slope of table, than the fine and pasty sand.

The *mechanical* operations which ores undergo, take place commonly at their out-put from the mine, and without any intermediate operation. Sometimes, however, the hardness of certain *gangues* (vein-stones), and of certain iron ores, is diminished by subjecting them to calcination previously to the breaking and stamping processes.

When it is intended to wash certain ores, an operation founded on the difference of their specific gravities, it may happen that by slightly changing the chemical state of the substances that compose the ore, the earthy parts may become more easily separable, as also the other foreign matters. With this view, the ores of tin are subjected to a roasting, which by separating the arsenic, and oxydizing the copper which are intermixed, furnishes the means of obtaining, by the subsequent washing, an oxyde of tin much purer than could be otherwise procured. In general, however, these are rare cases; so that the washing almost always immediately succeeds the picking and stamping; and the roasting comes next, when it needs to be employed.

The operation of roasting is in general executed by various processes, relatively to the nature of the ores, the quality of the fuel, and to the object in view. The greatest economy ought to be studied in the fuel, as well as the labor; two most important circumstances, on account of the great masses operated upon.

Three principal methods may be distinguished; 1. the roasting in a heap in the open air, the most simple of the whole; 2. the roasting executed between little walls, and which may be called case-roasting (*rost-stadeln*, in German); and 3. roasting in furnaces.

We may remark, as to the description about to be given of these different processes, that in the first two, the fuel is always in immediate contact with the ore to be roasted, whilst in furnaces, this contact may or may not take place.

1. The roasting in the open air, and in heaps more or less considerable, is practised upon iron ores, and such as are pyritous or bituminous. The operation consists in general in spreading over a plane area, often bottomed with beaten clay, billets of wood arranged like the bars of a gridiron, and sometimes laid crosswise over one another, so as to form a uniform flat bed. Sometimes wood charcoal is scattered in, so as to fill up the interstices, and to prevent the ore from falling between the other pieces of the fuel. Coal is also employed in moderately small lumps; and even occasionally turf. The ore, either simply broken into pieces, or even sometimes under the form of *schlich*, is piled up over the fuel; most usually alternate beds of fuel and ore are formed.

The fire, kindled in general at the lower part, but sometimes, however, at the middle chimney, spreads from spot to spot, putting the operation in train. The combustion must be so conducted as to be slow and suffocated, to prolong the ustulation, and let the whole mass be equably penetrated with heat. The means employed to direct the fire, are to cover outwardly with earth the portions where too much activity is displayed, and to pierce with holes or to give air to those where it is imperfectly developed. Rains, winds, variable seasons, and especially good primary arrangements of a calcination, have much influence on this process, which requires, besides, an almost incessant inspection at the beginning.

Nothing in general can be said as to the consumption of fuel, because it varies with its quality, as well as with the ores and the purpose in view. But it may be laid down as a good rule, to employ no more fuel than is strictly necessary for the kind of calcination in hand, and for supporting the combustion; for an excess of fuel would produce, besides an expense uselessly incurred, the inconvenience, at times very serious, of such a heat as may melt or vitrify the ores; a result entirely the reverse of a well-conducted ustulation.

Figs. 681, 682, 683, represent the roasting in mounds, as practised near Goslar in the Hartz, and at Chessy in the department of the Rhone. *Fig.* 681 is a vertical section in the line *h c* of *figs.* 682 and 683. In *fig.* 682 there is shown in plan, only a little more than one half of the quadrangular truncated pyramid, which constitutes the heap. *Fig.* 683 shows a little more than one fourth of a bed of wood, arranged at the bottom of the pyramid, as shown by *a a*, *fig.* 681, and *c g h*, *fig.* 683. c is a wooden chimney, formed within the heap of ore, at whose bottom *c* there is a little parcel of charcoal; *d d* are large lumps of ore distributed upon the wooden pile *a a*; *e e* are smaller fragments, to cover the larger; *f f* is rubbish and clay laid smoothly in a slope over the whole. *g*, *fig.* 683, a passage for air left under the bed of billets; of which there is a similar one in each of the four sides of the base *a a*, so that two principal currents of air cross under the upright axis c c, of the truncated pyramid indicated in *fig.* 681.

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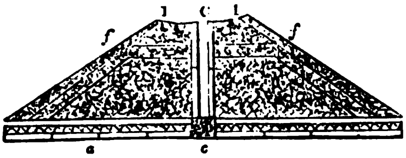

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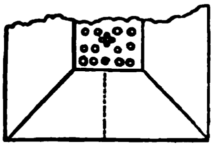

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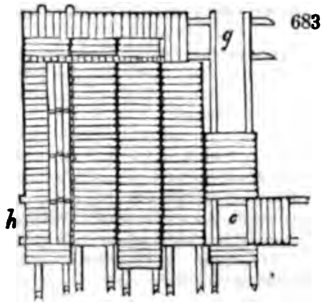

The kindling is thrown in by the chimney c. The charcoal *c*, and the wood *a a*, take fire; the sulphureous ores *d e f* are heated to such a high temperature as to vaporize the sulphur. In the Lower Hartz, a heap of this kind continues roasting during four months.

2. The second method. The difficulty of managing the fire in the roasting of substances containing little sulphur, with the greater difficulty of arranging and supporting in their place the *schlichs* to be roasted, and last of all, the necessity of giving successive fires to the same ores, or to inconsiderable quantities at a time, have led to the contrivance of surrounding the area on which the roasting takes place with three little walls, or with four, leaving a door in the one in front. This is what is called a *walled area*, and sometimes, improperly enough, a roasting furnace. Inside of these little walls, about 3 feet high, there are often vertical conduits or chimneys made to correspond with an opening on the ground level, in order to excite a draught of air in the adjacent parts. When the roasting is once set agoing, these chimneys can be opened or shut at their upper ends, according to the necessities of the process.

Several such furnaces are usually erected in connexion with each other by their lateral walls, and all terminated by a common wall, which forms their posterior part; sometimes they are covered with a shed supported partly by the back wall, built sufficiently high for this purpose. These dispositions are suitable for the roasting of *schlichs*, and in general of all matters which are to have several fires; a circumstance often indispensable to a due separation of the sulphur, arsenic, &c.

3 The furnaces employed for roasting the ores and the *mattes* differ much, according

to the nature of the ores, and the size of the lumps. We shall content ourselves with referring to the principal forms.

When iron ores are to be roasted, which require but a simple calcination to disengage the combined water and carbonic acid, egg-shaped furnaces, similar to those in which limestone is burned in contact with fuel, may be conveniently employed; and they present the advantage of an operation which is continuous with a never-cooling apparatus. The analogy in the effects to be produced is so perfect, that the same furnace may be used for either object. Greater dimensions may, however, be given to those destined for the calcination of iron ores. But it must be remembered that this process is applicable only to ores broken into lumps, and not to ores in grains or powder.

It has been attempted to employ the same method a little modified, for the roasting of ores of sulphuret of copper and pyrites, with the view of extracting a part of the sulphur. More or less succeess has ensued, but without ever surmounting all the obstacles arising from the great fusibility of the sulphuret of iron. For sometimes it runs into one mass, or at least into lumps agglutinated together in certain parts of the furnace, and the operation is either stopped altogether, or becomes more or less languid; the air not being able to penetrate into all the parts, the roasting becomes consequently imperfect. This inconvenience is even more serious than might at first sight appear; for, as the ill-roasted ores now contain too little sulphur to support their combustion, and as they sometimes fall into small fragments in the cooling, they cannot be passed again through the same furnace, and it becomes necessary to finish the roasting in a reverberatory hearth, which is much more expensive.

In the Pyrenees, the roasting of iron ores is executed in a circular furnace, so disposed that the fuel is contained and burned in a kind of interior oven, above which lie the pieces of ore to be calcined. Sometimes the vault of this oven, which sustains the ore, is formed of bricks, leaving between them openings for the passage of the flame and the smoke, and the apparatus then resembles certain pottery kilns; at other times the vault is formed of large lumps of ore, carefully arranged as to the intervals requisite to be left for draught over the arch. The broken ore is then distributed above this arch, care being taken to place the larger pieces undermost. This process is simple in the construction of the furnace, and economical, as branches of trees, without value in the forest, may be employed in the roasting. See *Lime-kiln* figures.

In some other countries, the ores are roasted in furnaces very like those in which porcelain is baked; that is to say, the fuel is placed exteriorly to the body of the furnace in a kind of brick shafts, and the flame traverses the broken ore with which the furnace is filled. In such an apparatus the calcination is continuous.

When it is proposed to extract the sulphur from the iron pyrites, or from pyritous minerals, different furnaces may be employed, among which that used in Hungary deserves notice. It is a rectangular parallelopiped of four walls, each of them being perforated with holes and vertical conduits which lead into chambers of condensation, where the sulphur is collected. The ore placed between the four walls on billets of wood arranged as in *figs.* 681, 682, 683, for the great roastings in the open air, is calcined with the disengagement of much sulphur, which finds more facility in escaping by the lateral conduits in the walls, than up through the whole mass, or across the upper surface covered over with earth; whence it passes into the chambers of condensation. In this way upwards of a thousand tons of pyrites may be roasted at once, and a large quantity of sulphur obtained.—See Copper.

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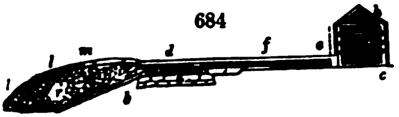

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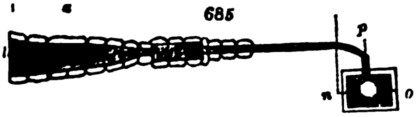

Roasting of Pyrites.—*Figs.* 684, 685, represent a furnace which has been long employed at Fahlun in Sweden, and several other parts of that kingdom, for roasting iron pyrites in order to obtain sulphur. This apparatus was constructed by the celebrated Gahn. *Fig.* 684 is a vertical section, in the line *k d n o* of *fig.* 685, which is a plan of the furnace; the top being supposed to be taken off. In both figures the conduit may be imagined to be broken off at *e*; its entire length in a straight line is 43 feet beyond the dotted line, *e n*, before the bend, which is an extension of this conduit. Upon the slope *a b* of a hillock *a b c*, lumps *r* of iron pyrites are piled upon the pieces of wood *i i* for roasting. A conduit *d f e* forms the continuation of the space denoted by *r*, which is covered by stone slabs so far as *f*; and from this point to the chamber *h* it is constructed in boards. At the beginning of this conduit, there is a recipient *g*. The chamber *h* is divided into five chambers by horizontal partitions, which permit the circulation of the vapors from one compartment to another. The ores *r* being distributed upon the billets of wood *i i*, whenever these are fairly kindled, they are covered with small ore, and then with rammed earth *l l*. Towards the point *m*, for a space of a foot square, the ores are covered with moveable stone slabs, by means of which the fire may be regulated, by the displacement of one or more, as may be deemed necessary. The liquid sulphur runs into the recipient g, whence it is laded out from time to time. The sublimed sulphur passes into the conduit *f e* and the chamber *h*, from which it is taken out, and washed with water, to free it from sulphuric acid, with which it is somewhat impregnated; it is afterwards distilled in cast-iron retorts. The residuum of the pyrites is turned to account in Sweden, for the preparation of a common red color much used as a pigment for wooden buildings.

The reverberatory furnace affords one of the best means of ustulation, where it is requisite to employ the simultaneous action of heat and atmospherical air to destroy certain combinations, and to decompose the sulphurets, arseniurets, &c. It is likewise evident that the facility thus offered of stirring the matters spread out on the sole, in order to renew the surfaces, of observing their appearances, of augmenting or diminishing the degree of heat, &c., promise a success much surer, a roasting far better executed, than by any other process. It is known, besides, that flame mingled with much undecomposed air issuing from the furnace, is highly oxydizing, and is very fit for burning away the sulphur, and oxydizing the metals. Finally, this is almost the only method of rightly roasting ores which are in a very fine powder. If it be not employed constantly and for every kind of ore, it is just because more economy is found in practising calcination in heaps, or on areas enclosed by walls; besides, in certain mines, a very great number of these furnaces, and many workmen, would be required to roast the considerable body of ores that must be daily smelted. Hence there would result from the construction of such apparatus and its maintenance a very notable outlay, which is saved in the other processes.

But in every case where it is desired to have a very perfect roasting, as for blende from which zinc is to be extracted, for sulphuret of antimony, &c., or even for ores reduced to a very fine powder, and destined for amalgamation, it is proper to perform the operation in a reverberatory furnace. When very fusible sulphurous ores are treated, the workman charged with the calcination must employ much care and experience, chiefly in the management of the fire. It will sometimes, indeed, happen, that the ore partially fuses; when it becomes necessary to withdraw the materials from the furnace, to let them cool and grind them anew, in order to recommence the operation. The construction of these furnaces demands no other attention than to give to the sole or laboratory the suitable size, and so to proportion to this the grate and the chimney that the heating may be effected with the greatest economy.

The reverberatory furnace is always employed to roast the ores of precious metals, and especially those for amalgamation; as the latter often contain arsenic, antimony, and other volatile substances, they must be disposed of in a peculiar manner.

The sole, usually very spacious, is divided into two parts, of which the one farthest off from the furnace is a little higher than the other. Above the vault there is a space or chamber in which the ore is deposited, and which communicates with the laboratory by a vertical passage; which serves to allow the ore to be pushed down, when it is dried and a little heated. The flame and the smoke which escape from the sole or laboratory pass into condensing chambers, before entering into the chimney of draught, so as to deposite in them the oxyde of arsenic and other substances. When the ore on the part of the sole farthest from the grate has suffered so much heat as to begin to be roasted, has become less fusible, and when the roasting of that in the nearer part of the sole is completed, the former is raked towards the fire-bridge, and its ustulation is finished by stirring it over frequently with a paddle, skilfully worked, through one of the doors left in the side for this purpose. The operation is considered to be finished when the vapors and the smell have almost wholly ceased; its duration depending obviously on the nature of the ores.

When this furnace is employed to roast very arsenical ores, as the tin ores of Schlackenwald in Bohemia, and at Ehrenfriedensdorf in Saxony, the arsenical pyrites of Geyer (in Saxony), &c., the chambers of condensation for the arsenious acid are much more extensive than in the furnaces commonly used for roasting galena, copper, or even silver ores.

Figs. 686, 687, 688 represent a reverberatory furnace employed in the smelting works of Lautenthal, in the Hartz, for roasting the schlichs of lead ores, which contain much blende or sulphuret of zinc. In *fig.* 686 we see that the two parts A B, B C, are absolutely like, the two furnaces being built in one body of brickwork. *Fig.* 687 is the plan of the furnace B C, taken at the level E F of *fig.* 686. *Fig.* 688 is a vertical section of the similar furnace A B, taken in the prolongation of the line G H in *fig. 687.*

a is the fire-place of the furnace, its grate and ash-pit. *b* is the conduit of vaporization, which communicates with the chambers *c*; *c*, chambers into which the vaporized substances are deposited; *d*, chimney for the escape of the smoke of the fire-place *a*, after it has gone through the space *b c c*; *e'*, is the charging door, with a hook hanging in front to rest the long iron rake upon, with which the materials are turned over; *f*, chamber containing a quantity of schlich destined for roasting; this chamber communicates with the vaulted corridor (gallery) D, seen in *fig.* 686; *g*, orifice through which the schlich is thrown into the furnace; *h*, area or hearth of the reverberatory furnace, of which the roof is certainly much too high; *i*, channels for the escape of the watery vapors; *k*, *l*, front arcade, between which and the furnace, properly speaking, are the two orifices of the conduits, which terminate at the channels *m*, *m'*. *m* is the channel for carrying towards the chimney *d*, the vapors which escape by the door *e'*. *n* is a walled-up door, which is opened from time to time, to take out of the chambers *c*, *c*, the substances that may be deposited in them.

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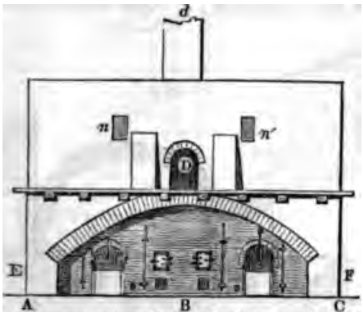

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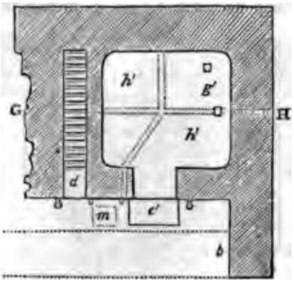

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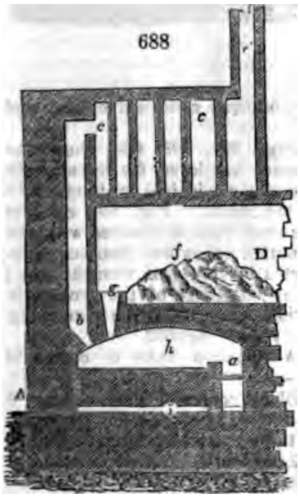

At the smelting works of Lautenthal, in such a roasting furnace, from 6 to 9 quintals (cwts.) of schlich are treated at a time, and it is stirred frequently with an iron rake upon the altar *h*. The period of this operation is from 6 to 12 hours, according as the schlich may be more or less dry, more or less rich in lead, or more or less charged with blende. When the latter substance is abundant, the process requires 12 hours, with about 60 cubic feet of cleft billets for fuel.

In such furnaces are roasted the cobalt ores of Schneeberg in Saxony, the tin ores of Schlackenwald in Bohemia, of Ehrenfriedersdorf in Saxony, and elsewhere; as also the arsenical pyrites at Geyer in Saxony. But there are poison towers and extensive condensing chambers attached in the latter case. See ARSENIC.

Figs. 689, 690, 691 represent the reverberatory furnace generally employed in the Hartz, in the district of Mansfeldt, Saxony, Hungary, &c., for the treatment of black copper, and for refining rose copper upon the great scale. An analogous furnace is used at Andreasberg for the liquefaction or purification of the mattes, and for workable lead when it is much loaded with arsenic.

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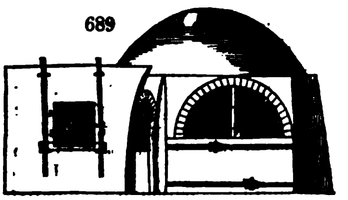
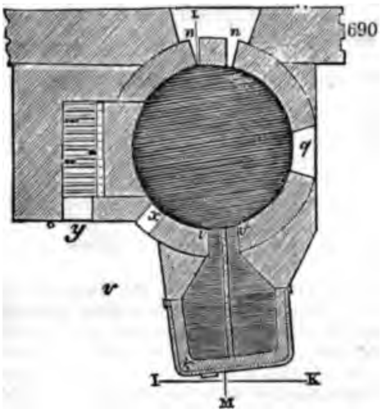


Fig. 689 presents the elevation of the furnace parallel to the line I K, of the plan *fig.* 690; which plan is taken at the level of the tuyère *n*, of *fig.* 691; *fig.* 691 is a vertical section in the line L M, *fig.* 690. *k* represents one of two basins of reception, brasqued with clay and charcoal; *n*, *n*, two tuyères, through which enters the blast of two pairs of bellows, like those shown at Cupellation of SILVER; *q*, door by which the matter to be melted is laid upon the sole of the furnace; *v*, *v*, two points where the sole is perforated, when necessary to run off the melted matter into either of the basins *h*; *x*, door through which the slags or cinders floating upon the surface of the melted metal are raked out; y, door of the fire-place. The fuel is laid upon a grate above an ash-pit, and below the arch of a reverberatory which is contiguous to the dome or cap of the furnace properly so called. In the section, *fig.* 691, the following parts may be noted; 1, 2, 3, mason-work of the foundation; 4, vapor channels or conduits, for the escape of the humidity; 5, bed of clay; 6, brasque composed of clay and charcoal, which forms the concavity of the hearth.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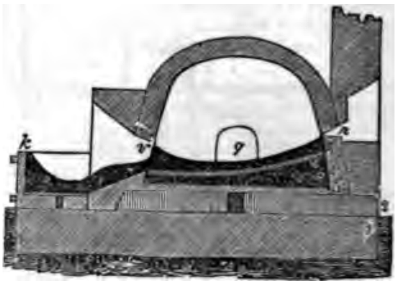

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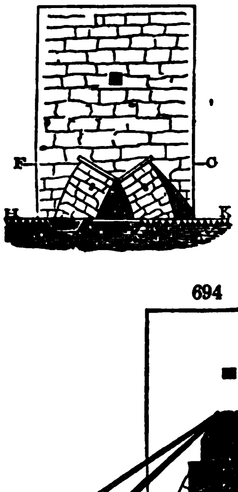

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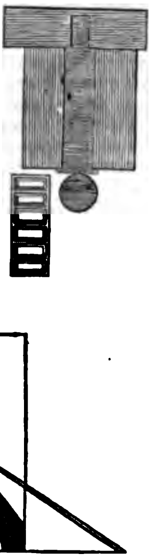

Figs. 692, 693, 694, show the furnace employed for liquation in one of the principal smelting works of the Hartz. *Fig.* 694 exhibits the working area charged with the liquation cakes and charcoal, supported by sheets of wrought iron; being an image of the process in action. *Fig.* 693 is the plan, in the line F G, of *fig.* 692.

A liquation cake is composed of—

Black copper holding at least 5 or 6 *loths* (2½ or 3 oz.) of silver per cwt., and weighing 90 to 96 lbs.

Lead obtained from litharge, 2 cwts. Litharge, ½ cwt.

From 30 to 32 cakes are successively worked in one operation, which lasts about 5 hours; the furnace is brought into action, as usual, with the aid of slags; then a little litharge is added; when the lead begins to flow, the copper is introduced, and when the copper flows, lead is added, so that the mixture of the metals may be effected in the best way possible.

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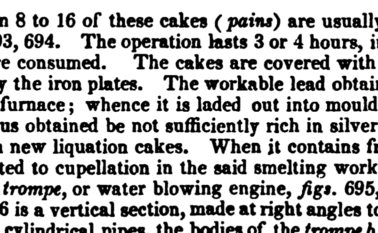

From 8 to 16 of these cakes (*pains*) are usually placed in the liquation furnace, *figs.* 692, 693, 694. The operation lasts 3 or 4 hours, in which time about 1½ quintals of charcoal are consumed. The cakes are covered with burning charcoal, supported, as I have said, by the iron plates. The workable lead obtained flows off towards the basin in front of the furnace; whence it is laded out into moulds set alongside. See *fig.* 693. If the lead thus obtained be not sufficiently rich in silver to be worth cupellation, it is employed to form new liquation cakes. When it contains from 5 to 6 loths of silver per cwt., it is submitted to cupellation in the said smelting works. See SILVER.

The *trompe*, or water blowing engine, *figs.* 695, 696, 697. *Fig.* 695 is the elevation; *fig.* 696 is a vertical section, made at right angles to the elevation. The machine is formed of two cylindrical pipes, the bodies of the *trompe b b*, set upright, called the funnels, which terminate above in a water cistern *a*, and below in a close basin under *c*, called the *tub* or *drum.* The conical part *p*, of the funnel has been called *etranguillon*, being *strangled*, as it were, in order that the water discharged into the body of the trompe shall not fill the pipe in falling, but be divided into many streamlets. Below this *narrow part*, eight holes, *q q*, are perforated obliquely through the substance of the trompe, called the vent-holes or nostrils, for admitting the air, which the water carries with it in its descent. The air afterwards parts from the water, by dashing upon a cast-iron slab, placed in the *drum* upon the pedestal *d*. An aperture *l*, at the bottom of the drum, allows the water to flow away after its fall; but, to prevent the air from escaping along with it, the water as it issues is received in a chest *l m n o*, divided into two parts by a vertical slide-plate between *m n*. By raising or lowering this plate, the water may be maintained at any desired level within the drum, so as to give the included air any determinate degree of pressure. The superfluous water then flows off by the hole *o*.

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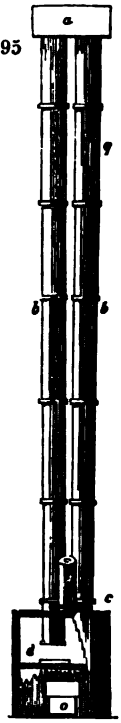

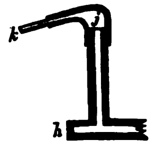

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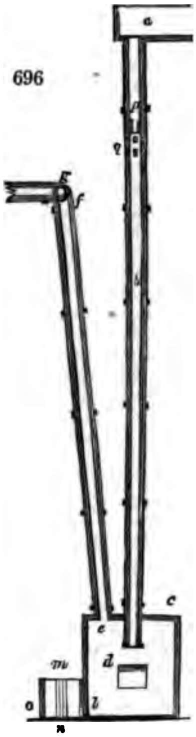

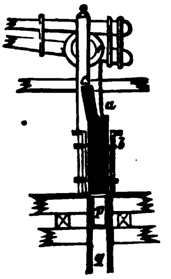

The air-pipe *e*, *fig.* 696, is fitted to the upper part of the *drum;* it is divided, at the point *f*, into three tubes, of which the principal one is destined for the furnace of cupellation, while the other two *g g*, serve for different melting furnaces. Each of these tubes ends in a leather pocket, and an iron nose-pipe *k*, adjusted in the tuyère of the furnace. At Pesey, and in the whole of Savoy, a floodgate is fitted into the upper cistern *a*, to regulate the admission of water into the trompe; but in Carniola, the funnel *p* is closed with a wooden plug, suspended to a cord, which goes round a pulley mounted upon a horizontal axis, as shown in *fig.* 697. By the plug *a* being raised more or less, merely the quantity of water required for the operation is admitted. The plug is pierced lengthwise with an oblique hole *c c*, in which the small tube *c* is inserted, with its top some way above the water level, through which air may be admitted into the heart of the column descending into the trompe *p q*.

The ordinary height of the trompe apparatus is about 26 or 27 feet to the upper level of the water cistern; its total length is 11 mètres (36 feet 6 inches), and its width 2 feet, to give room for the drums. It is situated 10 mètres (33½ feet) from the melting furnace. This is the case at the smelting works of Jauerberg, in Upper Carniola.

OF THE ASSAY OF ORES.

Assays ought to occupy an important place in metallurgic instructions, and there is reason to believe that the knowledge of assaying is not sufficiently diffused, since its practice is so often neglected in smelting houses. Not only ought the assays of the ores under treatment to be frequently repeated, because their nature is subject to vary; but the different products of the furnaces should be subjected to reiterated assays, at the several periods of the operations. When silver or gold ores are in question, the docimastic operations, then indispensable, exercise a salutary control over the metallurgic processes, and afford a clear indication of the quantities of precious metal which they ought to produce.

By the title *Assays*, in a metallurgic point of view, is meant the method of ascertaining for any substance whatever, not only the presence and the nature of a metal, but its proportional quantity. Hence the operations which do not lead to a precise determination of the metal in question, are not to be arranged among the assays now under consideration. Experiments made with the blow-pipe, although capable of yielding most useful indications, are like the touchstone in regard to gold, and do not constitute genuine assays.

Three kinds of assays may be practised in different circumstances, and with more or less advantage upon different ores. 1. The mechanical assay; 2. the assay by the dry way; 3. the assay by the humid way.

1. *Of mechanical assays.*—These kinds of assays consist in the separation of the substances mechanically mixed in the ores, and are performed by a hand-washing, in a small trough of an oblong shape, called a *sebilla*. After pulverizing with more or less pains the matters to be assayed by this process, a determinate weight of them is put into this wooden bowl with a little water; and by means of certain movements and some precautions, to be learned only by practice, the lightest substances may be pretty exactly separated, namely, the earthy gangues from the denser matter or metallic particles, without losing any sensible portion of them. Thus a *schlich* of greater or less purity will be obtained, which may afford the means of judging by its quality of the richness of the assayed ores, and which may thereafter be subjected to assays of another kind, whereby the whole metal may be insulated.

Washing, as an assay, is practised on auriferous sands; on all ores from the *stamps*, and even on *schlichs* already washed upon the great scale, to appreciate more nicely the degree of purity they have acquired. The ores of tin in which the oxyde is often disseminated in much earthy gangue, are well adapted to this species of assay, because the tin oxyde is very dense. The mechanical assay may also be employed in reference to the ores whose metallic portion presents a uniform composition, provided it also possesses considerable specific gravity. Thus the ores of sulphuret of lead (galena) being susceptible of becoming almost pure sulphurets (within 1 or 2 *per cent.*) by mere washing skilfully conducted, the richness of that ore in pure galena, and consequently in lead, may be at once concluded; since 120 of galena contain 104 of lead, and 16 of sulphur. The sulphuret of antimony mingled with its gangue may be subjected to the same mode of assay, and the result will be still more direct, since the crude antimony is brought into the market after being freed from its gangue by a simple fusion.

The assay by washing is also had recourse to for ascertaining if the *scoriæ* or other products of the furnaces contain some metallic grains which might be extracted from them by stamping and washing on the great scale; a process employed considerably with the *scoriæ* of tin and copper works.

Of assays by the dry way.—The assay by the dry way has for its object, to show the nature and proportion of the metals contained in a mineral substance. To make a good assay, however, it is indispensably necessary to know what is the metal associated with it, and even within certain limits, the quantity of the foreign bodies. Only one metal is commonly looked after; unless in the case of certain argentiferous ores. The mineralogical examination of the substances under treatment, is most commonly sufficient to afford data in these respects; but the assays may always be varied with different views, before stopping at a definite result; and in every instance, only such assays can be confided in, as have been verified by a double operation.

This mode of assaying requires only a little experience, with a simple apparatus; and is of such a nature as to be practised currently in the smelting works. The air furnace and crucibles employed are described in all good elementary chemical books. These assays are usually performed with the addition of a flux to the ore, or some agent for separating the earthy from the metallic substances; and they possess a peculiar advantage relative to the smelting operations, because they offer many analogies between results on the great scale and experiments on the small. This may even enable us often to deduce, from the manner in which the assay has succeeded with a certain flux, and at a certain degree of heat, valuable indications as to the treatment of the ore in the great way. See FURNACE.

In the smelting houses which purchase the ore, as in Germany, it is necessary to bestow much attention upon the assays, because they serve to regulate the quality and the price of the schlichs to be delivered. These assays are not by any means free from difficulties, especially when ores containing several useful metals are treated, and which are to be dosed or proportioned; ores, for example, including a notable quantity of lead, copper, and silver, mixed together.

In the central works of the Hartz, as well as in those of Saxony, the *schlichs* as delivered are subjected to docimastic assays, which are verified three times, and by three different persons, one of whom is engaged for the interests of the mining partners, another for that of the smelting house, and a third as arbiter in case of a difference. If the first two results of assaying differ by ⅛ *loth* (or ¼ ounce) of silver per cwt. of *schlich*, the operations must be resumed; but this rarely happens. When out of the three assays, the one differs from the two others by no more than ¼ loth of silver per cwt., but by more in one, and by less in another, the mean result is adopted. As to the contents of the *schlich* in lead, the mean results of the assays must be taken. The differences allowed are three pounds for the *schlich*, when it contains from 12 to 30 per cent. of lead, increasing to six pounds for *schlich*, when it contains less than 55 per cent. of that metal.

Assaying forms, in great establishments, an important object in reference to time and expense. Thus, in the single work of Franckenscharn, in the Hartz, no less than 300 assays have to be made in a threefold way, every Monday, without taking into account the several assays of the smelting products which take place every Thursday. Formerly fluxes more or less compound were employed for these purposes, and every assay cost about fifteen pence. At present all these assays are made more simply, by much cheaper methods, and cost a penny farthing each upon an average.

Of the assays by the humid way.—The assays by the humid way, not reducible to very simple processes, are true chemical analyses, which may in fact be applied with much advantage, either to ores, or to the products of the furnace; but which cannot be expected to be practised in smelting-houses, on account of the complication of apparatus and reagents they require. Moreover, an expert chemist is necessary to obtain results that can be depended on. The directors of smelting-houses, however, should never neglect any opportunities that may occur of submitting the materials operated upon, as well as their products, to a more thorough examination than the dry way alone can effect. One of the great advantages of similar researches is to discover and appreciate the minute quantities of injurious substances which impair the malleability of the metals, which give them several bad qualities, about whose nature and cause more or less error and uncertainty prevail. Chemical analysis, rightly applied to metallurgy, cannot fail to introduce remarkable improvements into the processes. See the different metals, in their alphabetical places.

For assays in the dry way, both of stony and metallic minerals, the process of Dr. Abich deserves recommendation. It consists in mixing the pulverized mineral with 4 or 6 times its weight of carbonate of baryta in powder, fusing the mixture at a white heat, and then dissolving it, after it cools, in dilute muriatic acid. The most refractory minerals, even corundum, cyanate, staurolite, zircon, and feldspar, yield readily to this treatment. This process may be employed with advantage upon poor refractory ores. The platinum crucible, into which the mixed materials are put for fusion, should be placed in a Hessian crucible, and surrounded with good coke.

The following tabular view of the metallic produce of the British mines is given by two very skilful observers, in a work published in 1827, entitled *Voyage Metallurgique en Angleterre, par MM. Dufrénoy et Elie de Beaumont*:—

		Tons.	Tons.
Tin	Cornwall alone	-	3,160
Copper	Cornwall	9,331	11,469
	Devonshire	537	
	Staffordshire	38	
	Anglesey	738	
	Wales	55	
	Cumberland	21	
	Ireland	738	
	Scotland	11	
Lead	Wales	7,500	31,900
	Scotland	2,800	
	Cornwall and Devonshire	800	
	Shropshire	800	
	Derbyshire	1,000	
	Cumberland	19,000	
Cast Iron	about	-	600,000*

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* I have converted the weights of lead and cast-iron, given in kilogrammes, into tons, at the rate of 1000 kilogrammes per ton; which is sufficiently near.

The manganese raised in England exceeds 2000 tons.

M. Heron de Villefosse inserted in the last number of the *Annales des Mines* for 1827, the following statistical view of the metallic products of France:—

	Tons.
Lead in pigs (*saumons*)	103
Litharge	513
Sulphuret of lead, ground galena (*alquifoux*)	112
Black copper	164
Antimony	91
Manganese	765
Crude cast-iron	25,606
Bar iron	127,643
Steel	3,500
Silver in ingots	$1\frac{1}{6}$

The total value of which is estimated at 80 millions of francs; or about 3,400,000 pounds sterling.

METALS (*Metaux*, Fr.; *Metalle*, Germ.) are by far the most numerous class of undecompounded bodies in chemical arrangements. They amount to 41; of which 7 form, with oxygen, bodies possessed of alkaline properties: these are, 1. potassium; 2. sodium; 3. lithium; 4. barytium, or barium; 5. strontium; 6. calcium; 7. magnesium; for even magnesia, the last and feeblest base, tinges turmeric brown, and red cabbage green. The next 5 metals form, with oxygen, the earths proper; they are, 8. yttrium; 9. glucinum; 10. alumium; 11. zirconium; 12. thorinum. The remaining 29 may be enumerated in alphabetical order, as they hardly admit of being grouped into subdivisions with any advantage. They are as follows: 13. antimony; 14. arsenic; 15. bismuth; 16. cadmium; 17. cerium; 18. chromium; 19. cobalt; 20. copper; 21. gold; 22. iridium; 23. iron; 24. lead; 25. manganese; 26. mercury; 27. molydenum; 28. nickel; 29. osmium; 30. palladium; 31. platinum; 32. rhodium; 33. silver; 34. tantalum; 35. tellurium; 36. tin; 37. titanium; 38. tungstenium; 39. vanadium; 40. uranium; 41. zinc.

1. They are all, more or less, remarkable for a peculiar lustre, called the metallic. This property of strongly reflecting light is connected with a certain state of aggregation of their particles, but is possessed, superficially at least, by mica, animal charcoal, selenium, polished indigo;—bodies not at all metallic.

2. The metals are excellent conductors of caloric, and most of them also of electricity, though probably not all. According to Despretz, they possess the power of conducting heat according to the following numbers:—Gold, 1000; platinum, 981; silver, 973; copper, 898; iron, 374; zinc, 363; tin, 304; lead, 179·6.

Becquerel gives the following table of metals, as to electrical conduction:—

Copper, 100; gold, 93·6; silver, 73·6; zinc, 28·5; platina, 16·4; iron, 15·8; tin, 15·5; lead, 8·3; mercury, 3·5; potassium, 1·33.

The metals which hardly, if at all, conduct electricity, are zirconium, alumium, tantalum in powder, and tellurium.

3. Metals are probably opaque; yet gold leaf, as observed by Newton, seems to transmit the green rays, for objects placed behind it in the sunbeam appear green. This phenomena has, however, been ascribed to the rays of light passing through an infinite number of minute fissures in the thinly hammered gold.

4. All metals are capable of combining with oxygen, but with affinities and in quantities extremely different. Potassium and sodium have the strongest affinity for it; arsenic and chromium, the feeblest. Many metals become acids by a sufficient dose of oxygen, while with a smaller dose they constitute salifiable bases.

5. Metals combine with each other, forming a class of bodies called alloys, except when one of them is mercury, in which case the compound is styled an amalgam.

6. They combine with hydrogen into *hydrurets*; with carbon, into *carburets*; with sulphur, into *sulphurets*; with phosphorus, into *phosphurets*; with selenium, into *seleniurets*; with boron, into *borurets* (*borides?*); with chlorine, into *chlorides*; with iodine, into *iodides*; with cyanogen, into *cyanides*; with silicon, into *silicides*; and with fluorine, into *fluorides*.

7. Metallic salts are definite compounds, mostly crystalline, of the metallic oxydes with the acids. See HALOID.

METEORITES (*Aerolithes*, Fr.) are stones of a peculiar aspect and composition, which have fallen from the air.

METHYLE`NE, a peculiar liquid compound of carbon and hydrogen, extracted from pyroxylic spirit, which is reckoned to be a bi-hydrate of *methylène*.

MICA is a finely foliated mineral, of a pearly metallic lustre. It is harder than *gypsum*, but not so hard as calc-spar; flexible and elastic; spec. grav. 2·65. [illegible] an ingredient of granite and gneiss. The large sheets of mica exposed for sale in London, are mostly brought from Siberia. They are used, instead of glass, to enclose the fire, without concealing the flame, in certain stoves.

The mica of Fahlun, analyzed by Rose, afforded, silica, 46·22; alumina, 34·52; peroxyde? of iron, 6·04; potash, 8·22; magnesia, with oxyde of manganese, 2·11; fluoric acid, 1·09; water, 0·98.

MICROCOSMIC SALT; a term given to a salt extracted from human urine, because man was regarded by the alchemists as a miniature of the world, or the microcosm. It is a phosphate of soda and ammonia; and is now prepared by mixing equivalent proportions of phosphate of soda and phosphate of ammonia, each in solution, evaporating and crystallizing the mixture. A small excess of ammonia aids the crystallization.

MILK (*Lait*, Fr.; *Milche*, Germ.) owes its whiteness and opacity to an emulsion composed of the caseous matter and butter, with sugar of milk, extractive matters, salts, and free lactic acid; the latter of which causes fresh milk to redden litmus paper. Milk, in general, contains from 10 to 12 per cent. of solid matter, on being evaporated to dryness by a steam heat. The mean specific gravity of cows' milk is 1·030, but it is less if the milk be rich in cream. The specific gravity of the skimmed milk is 1·035; and of the cream is 1·0244. 100 parts of creamed milk contain—

Caseous matter, containing some butter,	2·600
Sugar of milk	3·500
Alcoholic extract, lactic acid, and lactates	0·600
Salts; muriate and phosphate of potash, and phosphate of lime	0·420
Water	92·875
Cream consists of—Butter separated by churning	4·5
Caseous matter precipitated by the coagulation of the milk of the butter	3·5
Butter-milk	92·0
	100·0

When milk contained in wire-corked bottles, is heated to the boiling point in a water bath, the oxygen of the included small portion of air under the cork seems to be carbonated, and the milk will afterwards keep fresh, it is said, for a year or two; as green gooseberries and peas do by the same treatment.

MILL-STONE, or Buhr-Stone. This interesting form of silica, which occurs in great masses, has a texture essentially cellular, the cells being irregular in number, shape, and size, and are often crossed by thin plates, or coarse fibres of silex. The Buhr-stone has a straight fracture, but it is not so brittle as flint, though its hardness is nearly the same. It is feebly translucent; its colors are pale and dead, of a whitish, grayish, or yellowish cast, sometimes with a tinge of blue.

The Buhr-stones usually occur in beds, which are sometimes continuous, and at others interrupted. These beds are placed amid deposites of sand, or argillaceous and ferruginous marls, which penetrate between them, filling their fissures and honeycomb cavities. Buhr-stones constitute a very rare geological formation, being found in abundance only in the mineral basin of Paris, and a few adjoining districts. Its place of superposition is well ascertained: it forms a part of the lacustrine, or fresh-water formation, which, in the locality alluded to, lies above the fossil-bone gypsum, and the stratum of sand and marine sandstone which covers it. Buhr-stone constitutes, therefore, the uppermost solid stratum of the crust of the globe; for above it there is nothing but alluvial soil, or diluvial gravel, sand, and loam.

Buhr-stones sometimes contain no organic forms, at others they seem as if stuffed full of fresh-water shells, or land shells and vegetables of inland growth. There is no exception known to this arrangement; but the shells have assumed a silicious nature, and their cavities are often bedecked with crystals of quartz. The best Buhr-stones for grinding corn, have about an equal proportion of solid matter, and of vacant space. The finest quarry of them is upon the high ground, near *La Ferte-sous-Jouarre*. The stones are quarried in the open air, and are cut out in cylinders, from one to two yards in diameter, by a series of iron and wooden wedges, gradually but equally inserted. The pieces of buhr-stones are afterwards cut in parallelopipeds, called *panes*, which are bound with iron hoops into large millstones. These pieces are exported chiefly to England and America. Good millstones of a bluish white color, with a regular proportion of cells, when six feet and a half in diameter, fetch 1200 francs a-piece, or 48*l.* sterling. A coarse conglomerate sandstone or breccia is, in some cases, used as a substitute for buhr-stones; but it is a poor one.

MINERAL WATERS. See Soda Water, and Waters, Mineral.

MINES, (*Bergwerke*, Germ.) Amidst the variety of bodies apparently infinite, which compose the crust of the globe, geologists have demonstrated the prevalence of a few general systems of rocks, to which they have given the name of *formations* or *deposites.* A large proportion of these mineral systems consists of parallel planes, whose length and breadth greatly exceed their thickness; on which account they are called stratified rocks; others occur in very thick blocks, without any parallel stratification, or horizontal seams of considerable extent.

The stratiform deposites are subdivided into two great classes; the primary and the secondary. The former seem to have been called into existence before the creation of organic matter, because they contain no exuviæ of vegetable or animal beings; while the latter are more or less interspersed, and sometimes replete with organic remains. The primary strata are characterized, moreover, by the nearly vertical or highly inclined position of their planes; the secondary lie for the most part in a nearly horizontal position.

Where the primitive mountains graduate down into the plains, rocks of an intermediate character appear, which, though possessing a nearly vertical position, contain a few vestiges of animal beings, especially shells. These have been called *transition*, to indicate their being the passing links between the first and second systems of ancient deposites; they are distinguished by the fractured and cemented texture of their planes, for which reason they are sometimes called conglomerate.

Between these and the truly secondary rocks, another very valuable series is interposed in certain districts of the globe; namely, the coal-measures, the paramount formation of Great Britain. The coal strata are disposed in a basin-form, and alternate with parallel beds of sandstone, slate-clay, iron-stone, and occasionally limestone. Some geologists have called the coal-measures the medial formation.

In every mineral plane, the inclination and direction are to be noted; the former being the angle which it forms with the horizon, the latter the point of the azimuth or horizon, towards which it dips, as west, north-east, south, &c. The direction of the bed is that of a horizontal line drawn in its plane; and which is also denoted by the point of the compass. Since the lines of direction and inclination are at right angles to each other, the first may always be inferred from the second; for when a stratum is said to dip to the east or west, this implies that its direction is north and south.

The smaller sinuosities of the bed are not taken into account, just as the windings of a river are neglected in stating the line of its course.

Masses are mineral deposites, not extensively spread in parallel planes, but irregular heaps, rounded or oval, enveloped in whole or in a great measure by rocks of a different kind. Lenticular masses being frequently placed between two horizontal or inclined strata, have been sometimes supposed to be stratiform themselves, and have been accordingly denominated by the Germans *liegende stocke, lying heaps* or *blocks.*

The orbicular masses often occur in the interior of unstratified mountains, or in the bosom of one bed.

Nests, concretions, nodules, are small masses found in the middle of strata; the first being commonly in a friable state; the second often kidney-shaped, or tuberous; the third nearly round, and incrusted, like the kernel of an almond.

Lodes, or large veins, are flattened masses, with their opposite surfaces not parallel, which consequently terminate like a wedge, at a greater or less distance, and do not run parallel with the rocky strata in which they lie, but cross them in a direction not far from the perpendicular; often traversing several different mineral planes. The *lodes* are sometimes deranged in their course, so as to pursue for a little way the space between two contiguous strata; at other times they divide into several branches. The matter which fills the lodes is for the most part entirely different from the rocks they pass through, or at least it possesses peculiar features.

This mode of existence, exhibited by several mineral substances, but which has been long known with regard to metallic ores, suggests the idea of clefts or rents having been made in the stratum posterior to its consolidation, and of the vacuities having been filled with foreign matter, either immediately or after a certain interval. There can be no doubt as to the justness of the first part of the proposition, for there may be observed round many lodes undeniable proofs of the movement or dislocation of the rock; for example, upon each side of the rent, the same strata are no longer situated in the same plane as before, but make greater or smaller angles with it; or the stratum upon one side of the lode is raised considerably above, or depressed considerably below, its counterpart upon the other side. With regard to the manner in which the rent has been filled, different opinions may be entertained. In the lodes which are widest near the surface of the ground, and graduate into a thin wedge below, the foreign matter would seem to have been introduced as into a funnel at the top, and to have carried along with it in its fluid state portions of rounded gravel and organic remains. In other cases, other conceptions seem to be more probable; since many lodes are largest at their under part, and become progressively narrower as they approach the surface; from which circumstance it has been inferred that the rent has been caused by an expansive force acting from within the earth, and that the foreign matter, having been injected in a fluid state, has afterwards slowly crystallized. This hypothesis accounts much better than the other for most of the phenomena observable in mineral veins, for the alterations of the rock at their sides, for the crystallization of the different substances interspersed in them, for the cavities bestudded with little crystals, and for many minute peculiarities. Thus, the large crystals of certain substances which line the walls of hollow veins, have sometimes their under surfaces besprinkled with small crystals of sulphurets, arseniurets, &c., while their upper surfaces are quite smooth; suggesting the idea of a slow sublimation of these volatile matters from below, by the residual heat, and their condensation upon the under faces of the crystalline bodies, already cooled. This phenomenon affords a strong indication of the igneous origin of metalliferous veins.

In the lodes, the principal matters which fill them are to be distinguished from the accessory substances; the latter being distributed irregularly, amidst the mass of the first, in crystals, nodules, grains, seams, &c. The non-metalliferous exterior portion, which is often the largest, is called *gangue*, from the German *gang*, *vein*. The position of a vein is denoted, like that of the strata, by the angle of inclination, and the point of the horizon towards which they dip, whence the direction is deduced.

Veins, are merely small lodes, which sometimes traverse the great ones, ramifying in various directions, and in different degrees of tenuity.

A metalliferous substance is said to be *disseminated*, when it is dispersed in crystals, spangles, scales, globules, &c., through a large mineral mass.

Certain ores which contain the metals most indispensable to human necessities, have been treasured up by the Creator in very bountiful deposites; constituting either great masses in rocks of different kinds, or distributed in lodes, veins, nests, concretions, or beds with stony and earthy admixtures; the whole of which become the objects of mineral exploration. These precious stores occur in different stages of the geological formations; but their main portion, after having existed abundantly in the several orders of the primary strata, suddenly cease to be found towards the middle of the secondary. Iron ores are the only ones which continue among the more modern deposites, even so high as the beds immediately beneath the chalk, when they also disappear, or exist merely as coloring matters of the tertiary earthy beds.

The strata of gneiss and mica-slate constitute in Europe the grand metallic domain. There is hardly any kind of ore which does not occur there in sufficient abundance to become the object of mining operations, and many are found nowhere else. The transition rocks, and the lower part of the secondary ones, are not so rich, neither do they contain the same variety of ores. But this order of things, which is presented by Great Britain, Germany, France, Sweden, and Norway, is far from forming a general law; since in equinoctial America the gneiss is but little metalliferous; while the superior strata, such as the clay-schists, the sienitic porphyries, the limestones, which complete the transition series, as also several secondary deposites, include the greater portion of the immense mineral wealth of that region of the globe.

All the substances of which the ordinary metals form the basis, are not equally abundant in nature; a great proportion of the numerous mineral species which figure in our classifications, are mere varieties scattered up and down in the cavities of the great masses or lodes. The workable ores are few in number, being mostly sulphurets, some oxydes, and carbonates. These occasionally form of themselves very large masses, but more frequently they are blended with lumps of quartz, feldspar, and carbonate of lime, which form the main body of the deposite; as happens always in proper lodes. The ores in that case are arranged in small layers parallel to the strata of the formation, or in small veins which traverse the rock in all directions, or in nests or concretions stationed irregularly, or finally disseminated in hardly visible particles. These deposites sometimes contain apparently only one species of ore, sometimes several, which must be mined together, as they seem to be of contemporaneous formation; whilst, in other cases, they are separable, having been probably formed at different epochs. In treating of the several metals in their alphabetical order, I have taken care to describe their peculiar geological positions, and the rocks which accompany or mineralize them.

In mining, as in architecture, the best method of imparting instruction is to display the master-pieces of the respective arts, which speak clearly to the mind through the medium of the eye. It is not so easy, however, to represent at once the general effect of a mine, as it is of an edifice; because there is no point of sight from which the former can be sketched at once, like the latter. The subterraneous structures certainly afford some of the finest examples of the useful labors of man, continued for ages, under the guidance of science and ingenuity; but, however curious, beautiful, and grand in themselves, they cannot become objects of a panoramic view. It is only by the lights of geometry and geology that mines can be contemplated and surveyed, either as a whole or in their details; and, therefore, these marvellous subterranean regions, in which roads are cut many hundred miles long, are altogether unknown or disregarded by men of the world. Should any of them, perchance, from curiosity or interest, descend into these dark recesses of the earth, they are prepared to discover only a few insulated objects which they may think strange or possibly hideous; but they cannot recognise either the symmetrical disposition of mineral bodies, or the laws which govern geological phenomena, and serve as sure guides to the skilful miner in his adventurous search. It is by exact plans and sections of subterraneous workings, that a knowledge of the nature, extent, and distribution of mineral wealth can be acquired.

698. *A general view of mining operations.*

As there is no country in the world so truly rich and powerful, by virtue of its mineral stores, as Great Britain, so there are no people who ought to take a deeper interest in their scientific illustration. I have endeavored in the present article to collect from the most authentic sources the most interesting and instructive examples of mining operations.

To the magnificent work of Ville-Fosse, *Sur la Richesse Minerale*, no longer on sale, I have to acknowledge weighty obligations; many of the figures being copied from his great Atlas.

Lodes or mineral veins are usually distinguished by English miners into at least four species. 1. The rake vein. 2. The pipe vein. 3. The flat or dilated vein; and 4. The interlaced mass (*stock-werke*), indicating the union of a multitude of small veins mixed in every possible direction with each other, and with the rock.

1. The *rake* vein is a perpendicular mineral fissure; and is the form best known among practical miners. It commonly runs in a straight line, beginning at the superficies of the strata, and cutting them downwards, generally further than can be reached. This vein sometimes stands quite perpendicular; but it more usually inclines or hangs over at a greater or smaller angle, or slope, which is called by the miners the *hade* or *hading* of the vein. The line of direction in which the fissure runs, is called the *bearing of the vein.*

2. The *pipe* vein resembles in many respects a huge irregular cavern, pushing forward into the body of the earth in a sloping direction, under various inclinations, from an angle of a few degrees to the horizon, to a dip of 45°, or more. The pipe does not in general cut the strata across like the rake vein, but insinuates itself between them; so that if the plane of the strata be nearly horizontal, the bearing of the pipe vein will be conformable; but if the strata stand up at a high angle, the pipe shoots down nearly headlong like a shaft. Some pipes are very wide and high, others are very low and narrow, sometimes not larger than a common mine or drift.

3. The *flat* or *dilated* vein, is a space or opening between two strata or beds of stone, the one of which lies above, and the other below this vein, like a stratum of coal

between its roof and pavement; so that the vein and the strata are placed in the same plane of inclination. These veins are subject, like coal, to be interrupted, broken, and thrown up or down by slips, dikes, or other interruptions of the regular strata. In the case of a metallic vein, a slip often increases the chance of finding more treasure. Such veins do not preserve the parallelism of their beds, characteristic of coal seams; but vary excessively in thickness within a moderate space. Flat veins occur frequently in limestone, either in a horizontal or declining direction. The flat or strata veins open and close, as the rake veins also do.

4. The interlaced mass has been already defined.

To these may be added the *accumulated* vein, or irregular mass (*butzenwerke*), a great deposite placed without any order in the bosom of the rocks, apparently filling up cavernous spaces.

The interlaced masses are more frequent in primitive formations, than in the others; and tin is the ore which most commonly affects this locality. See figure of TIN mine.

The study of the mineral substances, called *gangues* or vein-stones, which usually accompany the different ores, is indispensable in the investigation and working of mines. These *gangues*, such as quartz, calcareous spar, fluor spar, heavy spar, &c., and a great number of other substances, although of little or no value in themselves, become of great consequence to the miner, either by pointing out by their presence that of certain useful minerals, or by characterizing in their several associations, different deposites of ores of which it may be possible to follow the traces, and to discriminate the relations, often of a complicated kind, provided we observe assiduously the accompanying *gangues*.

Mineral veins are subject to derangements in their course, which are called shifts or faults. Thus, when a transverse vein throws out, or intercepts, a longitudinal one, we must commonly look for the rejected vein on the side of the obtuse angle which the direction of the latter makes with that of the former. When a bed of ore is deranged by a fault, we must observe whether the slip of the strata be upwards or downwards; for in either circumstance, it is only by pursuing the direction of the fault that we can recover the ore; in the former case by mounting, in the latter by descending beyond the dislocation.

When two veins intersect each other, the direction of the *offcast* is a subject of interest, both to the miner and the geologist. In Saxony it is considered as a general fact that the portion thrown out is always upon the side of the obtuse angle, a circumstance which holds also in Cornwall; and the more obtuse the angle, the out-throw is the more considerable. A vein may be thrown out on meeting another vein, in a line which approaches either towards its inclination or its direction. The Cornish miners use two different terms to denote these two modes of rejection; for the first case, they say the vein is *heaved*; for the second, it is *started*.

The great copper lode of Carharack, *d*, *fig.* 699, in the parish of Gwenap, is one of the most instructive examples of intersection. The power or thickness of this vein is 8 feet; its direction is nearly due east and west, and it dips towards the north at an inclination of two feet per fathom; its upper part being in the *killas* a greenish clay-slate); its lower part in the granite. The lode has suffered two intersections; the first produced by meeting the vein *h*, called *Steven's fluckan*, which runs from north-east to south-west, and which throws the lode several fathoms out; the second is produced by another vein *i*, almost at right angles with the first, and which occasions another outthrow of 20 fathoms to the right side. The fall of the vein occurs therefore in the one case to the right, and in the other to the left; but in both it is towards the side of the obtuse angle. This distribution is very singular; for one part of the vein appears to have mounted while the other has descended. N. S. denotes North and South. *d* is the copper lode running east and west. *h*, *i*, are systems of clay-slate veins called fluckans; the line over S, represents the down shift, and *d′* the up-shift.

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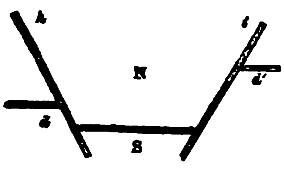


General observations on the localities of ores, and on the indications of metallic mines.

1. *Tin* exists principally in primitive rocks, appearing either in interlaced masses, in beds, or as a constituent part of the rock itself, and more rarely in distinct veins. Tin ore is found indeed sometimes in alluvial land, filling up low situations between lofty mountains.

2. *Gold* occurs either in beds or in veins, frequently in primitive rocks; though in other formations, and particularly in alluvial earth, it is also found. When this metal exists in the bosom of primitive rocks, it is particularly in schists; it is not found in serpentine, but it is met with in graywacke in Transylvania. The gold of alluvial districts,

called gold of washing or transport, occurs, as well as alluvial tin, among the debris of the more ancient rocks.

3. *Silver* is found particularly in veins and beds, in primitive and transition formations; though some veins of this metal occur in secondary strata. The rocks richest in it are, gneiss, mica-slate, clay-slate, graywacke, and old alpine limestone. Localities of silver-ore itself are not numerous, at least in Europe, among secondary formations; but it occurs in combination with the ores of copper or of lead.

4. *Copper* exists in the three mineral epochas; 1. in primitive rocks, principally in the state of pyritous copper, in beds, in masses, or in veins; 2. in transition districts, sometimes in masses, sometimes in veins of copper pyrites; 3. in secondary strata, especially in beds of cupreous schist.

5. *Lead* occurs also in each of the three mineral epochas; abounding particularly in primitive and transition grounds, where it usually constitutes veins, and occasionally beds of sulphureted lead (galena). The same ore is found in strata or in veins among secondary rocks, associated now and then with ochreous iron-oxyde and calamine (carbonate of zinc); and it is sometimes disseminated in grains through more recent strata.

6. *Iron* is met with in four different mineral eras, but in different ores. Among primitive rocks, magnetic iron ore and specular iron ore occur chiefly in beds, sometimes of enormous size; the ores of red or brown oxyde of iron (hematite) are found generally in veins, or occasionally in masses with sparry iron, both in primitive and transition rocks; as also sometimes in secondary strata; but more frequently in the coal-measure strata, as beds of clay-ironstone, of globular iron oxyde, and carbonate of iron. In alluvial districts we find ores of clay-ironstone, granular iron-ore, bog-ore, swamp-ore, and meadow-ore. The iron ores which belong to the primitive period have almost always the metallic aspect, with a richness amounting even to 80 per cent. of iron, while the ores in the posterior formations become in general more and more earthy, down to those in alluvial soils, some of which present the appearance of a common stone, and afford not more than 20 per cent. of metal, though its quality is often excellent.

7. *Mercury* occurs principally among secondary strata, in disseminated masses, along with combustible substances; though the metal is met with occasionally in primitive countries.

8. *Cobalt* belongs to the three mineral epochas; its most abundant deposites are veins in primitive rocks; small veins containing this metal are found, however, in secondary strata.

9. *Antimony* occurs in veins or beds among primitive and transition rocks.

10, 11. Bismuth and nickel do not appear to constitute the predominating substance of any mineral deposites; but they often accompany cobalt.

12. *Zinc* occurs in the three several formations: namely, as sulphuret or blende, particularly in primitive and transition rocks; as calamine, in secondary strata, usually along with oxyde of iron, and sometimes with sulphuret of lead.

An acquaintance with the general results collected and classified by geology must be our first guide in the investigation of mines. This enables the observer to judge whether any particular district should, from the nature and arrangement of its rocks, be susceptible of including within its bosom, beds of workable ores; it indicates also, to a certain degree, what substances may probably be met with in a given series of rocks, and what locality these substances will preferably affect. For want of a knowledge of these facts, many persons have gone blindly into researches equally absurd and ruinous.

Formerly, indications of mines were taken from very unimportant circumstances; from thermal waters, the heat of which was gratuitously referred to the decomposition of pyrites; from mineral waters, whose course is however often from a far distant source; from vapors incumbent over particular mountain groups; from the snows melting faster in one mineral district than another; from the different species of forest trees, and from the greater or less vigor of vegetation, &c. In general, all such indications are equally fallacious with the divining rod, and the compass made of a lump of pyrites suspended by a thread.

Geognostic observation has substituted more rational characters of metallic deposites, some of which may be called *negative* and others *positive*.

The *negative* indications are derived from that peculiar geological constitution, which from experience or general principles excludes certain metallic matters; for example, granite, and in general every primitive formation, forbids the hope of finding within them combustible fossils (pit-coal,) unless it be beds of anthracite; there also it would be vain to seek for sal gem. It is very seldom that granite rocks include silver; or limestones, ores of tin. Volcanic territories never afford any metallic ores worth the working; nor do extensive veins usually run into secondary and alluvial formations. The richer ores of iron do not occur in secondary strata; and the ores of this metal peculiar to these localities, do not exist among primary rocks.

Among *positive* indications, some are proximate and others remote. The proximate are, an efflorescence, so to speak, of the subjacent metallic masses; magnetic attraction for iron ores; bituminous stone, or inflammable gas for pit-coal; the frequent occurrence of fragments of particular ores, &c. The remote indications consist in the geological epochs, and nature of the rocks. From the examples previously adduced, marks of this kind acquire new importance when in a district susceptible of including deposites of workable ores, the *gangues* or vein-stones are met with which usually accompany any particular metal. The general aspect of mountains whose flanks present gentle and continuous slopes, the frequency of sterile veins, the presence of metalliferous sands, the neighborhood of some known locality of an ore, for instance, that of iron-stone in reference to coal, lastly, the existence of salt springs and mineral waters, may furnish some indications; but when ferruginous or cupreous waters issue from sands or clays, such characters merit in general little attention, because the waters may flow from a great distance. No greater importance can be attached to metalliferous sands and saline springs.

In speaking of remote indications, we may remark that in several places, and particularly near Clausthal in the Hartz, a certain ore of red oxyde of iron occurs above the most abundant deposites of the ores of lead and silver; whence it has been named by the Germans the *iron-hat.* It appears that the iron ore rich in silver, which is worked in America under the name of *pacos*, has some analogy with this substance; but iron ore is in general so plentifully diffused on the surface of the soil, that its presence can be regarded as only a remote indication, relative to other mineral substances, except in the case of clay iron-stone with coal.

Of the instruments and operations of subterranean operations.—It is by the aid of geometry in the first place that the miner studies the situation of the mineral deposites, on the surface and in the interior of the ground; determines the several relations of the veins and the rocks; and becomes capable of directing the perforations towards a suitable end.

The instruments are, 1. the magnetic compass, which is employed to measure the direction of a metallic ore, wherever the neighborhood of iron does not interfere with its functions; 2. the graduated semi-circle, which serves to measure the inclination, which is also called the clinometer.

3. The chain or cord for measuring the distance of one point from another.

4. When the neighborhood of iron renders the use of the magnet uncertain, a plate or plane table is employed.

The dials of the compasses generally used in the most celebrated mines, are graduated into hours; most commonly into twice 12 hours. Thus the whole limb is divided into 24 spaces, each of which contains 15° = 1 hour. Each hour is subdivided into 8 parts.

Means of penetrating into the interior of the earth.—In order to penetrate into the interior of the earth, and to extract from it the objects of his toils, the miner has at his disposal several means, which may be divided into three classes; 1. *manual tools*, 2. *gunpowder*, and 3. *fire.*

The tools used by the miners of Cornwall and Devonshire are the following:

Fig. 700. The *pick.* It is a light tool, and somewhat varied in shape according to circumstances. One side used as a hammer is called the *poll*, and is employed to drive in the *gads*, or to loosen and detach prominences. The *point* is of steel, carefully tempered, and drawn under the hammer to the proper form. The French call it *pointerolle.*

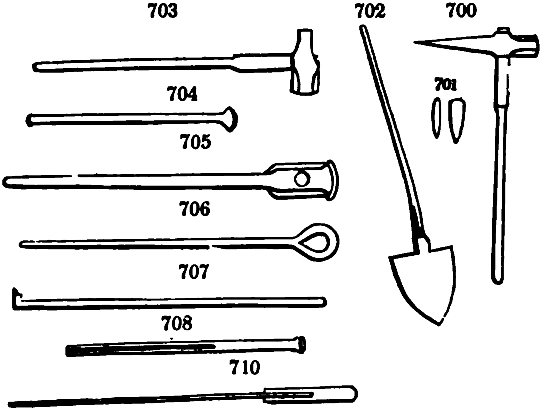


Fig. 701. The *gad.* It is a wedge of steel, driven into crevices of rocks, or into small openings made with the point of the pick.

Fig. 702. The *miner's shovel.* It has a pointed form, to enable it to penetrate among the coarse and hard fragments of the mine rubbish. Its handle being somewhat bent, a man's power may be conveniently applied without bending his body.

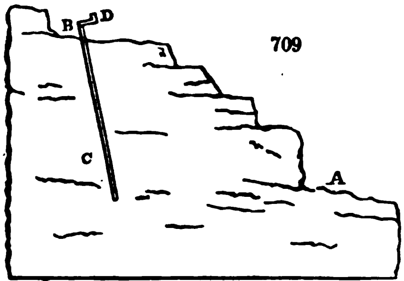
The *blasting* or *shooting* tools are:—

A sledge or mallet - - - - - -	*fig.* 703.
Borer - - - - - - - - - -	— 704.
Claying bar - - - - - - - -	— 705.
Needle or nail - - - - - - -	— 706.
Scraper - - - - - - - - - -	— 707.
Tamping bar - - - - - - -	— 708.

Besides these tools the miner requires a powder-horn, rushes to be filled with gunpowder, tin cartridges for occasional use in wet ground, and paper rubbed over with gunpowder or grease, for the *smifts* or fuses.

The *borer, fig.* 704, is an iron bar tipped with steel, formed like a thick chisel, and is used by one man holding it straight in the hole with constant rotation on its axis, while another strikes the head of it with the iron sledge or mallet, *fig.* 703. The hole is cleared out from time to time by the scraper, *fig.* 707, which is a flat iron rod turned up at one end. If the ground be very wet, and the hole gets full of mud, it is cleaned out by a stick bent at the end into a fibrous brush, called a *swab-stick.*

Fig. 709 represents the plan of blasting the rock, and a section of a hole ready for firing. The hole must be rendered as dry as possible, which is effected very simply by filling it partly with tenacious clay, and then driving into it a tapering iron rod, which nearly fills its calibre, called the *claying bar.* This being forced in with great violence, condenses the clay into all the crevices of the rock, and secures the dryness of the hole. Should this plan fail, recourse is had to tin cartridges furnished with a stem or tube, (see *fig.* 710,) through which the powder may be inflamed. When the hole is dry, and the charge of powder introduced, the *nail*, a small taper rod of copper, is inserted so as to reach the bottom of the hole, which is now ready for *tamping.* By this difficult and dangerous process, the gunpowder is confined, and the disruptive effect produced. Different substances are employed for *tamping*, or cramming the hole, the most usual one being any soft species of rock free from silicious or flinty particles. Small quantities of it only are introduced at a time, and rammed very hard by the *tamping-bar*, which is held steadily by one man, and struck with a sledge by another. The hole being thus filled, the nail is withdrawn by putting a bar through its eye, and striking it upwards. Thus a small perforation or vent is left for the rush which communicates the fire.


709

Besides the improved tamping-bar faced with hard copper, other contrivances have been resorted to for diminishing the risk of those dreadful accidents that frequently occur in this operation. Dry sand is sometimes used as a tamping material, but there are many rocks for the blasting of which it is ineffective. Tough clay will answer better in several situations.

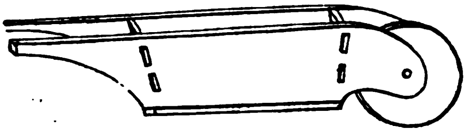
For conveying the fire, the large and long green rushes which grow in marshy ground are selected. A slit is made in one side of the rush, along which the sharp end of a bit of stick is drawn, so as to extract the pith, when the skin of the rush closes again by its own elasticity. This tube is filled up with gunpowder, dropped into the vent-hole, and made steady with a bit of clay. A paper *smift*, adjusted to burn a proper time, is then fixed to the top of the rush-tube, and kindled, when the men of the mine retire to a safe distance.

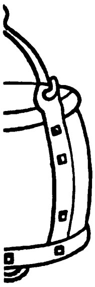
In *fig.* 709 the portion of the rock which would be dislodged by the explosion, is that included between A and B. The charge of powder is represented by the white part which fills the hole up to C; from which point to the top, the hole is filled with *tamping.* The *smift* is shown at D.

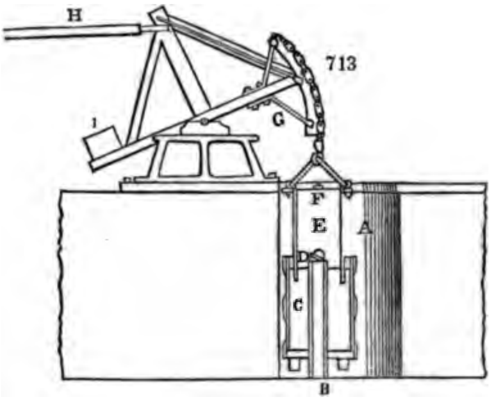
Fig. 711 is an iron bucket, or as it is called in Cornwall, a kibble, in which the ore is raised in the shafts, by machines called *whims*, worked by horses. The best kibbles

f sheet-iron, and hold each about three hundred weight of ore: 120 kibbles
ed to clear a cubic fathom of rock.

712







! represents the wheelbarrow used under ground for conveying ore and waste
of the shafts. It is made of light deal, except the wheel, which has a narrow

! represents Mr. Taylor's ingenious ventilator, or machine for renewing fresh
s. It is so simple in construction, so complete in its operation, requires so
r to work it, and is so little liable to injury from wear, that nothing further
l can be desired in ordinary metallic mines. The shaft of the mine is repre-
; at either the top or bottom of which the machine may be placed, as is
: convenient, but the foul air must be discharged into a floor, furnished with
or to prevent its return into the mine. B is the air-pipe from the mine, pass-
h the bottom of the fixed vessel or cylinder C, which is formed of timber, and
ı iron hoops. It is filled with water nearly to the top of the pipe B, on which
alve opening upwards at D. E, the air, or exhausting cylinder of cast-iron,
ttom, and suspended over the air-pipe, but immersed some way in the water.
hed with a wooden top, having an aperture fitted with a valve likewise open-
ls at F. This exhausting cylinder is moved up and down by the *bob*, G, brought
xion with any engine, by the horizontal rod H; the weight of the cylinder
aced, if necessary, by the counterpoise I. The action is as follows: — When
r rises, the air from the mine rushes up through the pipe and valve D; and
scends, this valve shuts, and prevents the return of the air, which is expelled
e valve F. With a cylinder two feet in diameter and six feet long, working
to three strokes per minute, 200 gallons of air may be discharged in the

der is the most valuable agent of excavation; possessing a power which has
nd which can act everywhere, even under water. Its introduction, in 1615,
reat revolution in the mining art.
ployed in mines in different manners, and in different quantities, according to
ces. In all cases, however, the process resolves itself into boring a hole, and
ı cartridge in it, which is afterwards made to explode. The hole is always
, and is usually made by means of the borer, *fig.* 704, a stem of iron, termi-
blunt-edged chisel. It sometimes ends in a cross, formed by two chisels set
y. The workman holds the stem in his left hand, and strikes it with an iron
l in his right. He is careful to turn the punch a very little round at every
everal punches are employed in succession, to bore one hole; the first shorter,
mes longer, and somewhat thinner. The rubbish is withdrawn as it accumu-
e bottom of the hole, by means of a picker, which is a small spoon or disc
ed at the end of a slender iron rod. When holes of a large size are to be

made, several men must be employed; one to hold the punch, and one or more to wield the iron mallet. The perforations are seldom less than an inch in diameter, and 18 inches deep; but they are sometimes two inches wide, with a depth of 50 inches.

The gunpowder, when used, is most commonly put up in paper cartridges. Into the side of the cartridge, a small cylindrical spindle or *piercer* is pushed. In this state the cartridge is forced down to the bottom of the hole, which is then stuffed, by means of the tamping bar, *fig.* 708, with bits of dry clay, or friable stones coarsely pounded.[*] The piercer is now withdrawn, which leaves in its place a channel through which fire may be conveyed to the charge. This is executed either by pouring gunpowder into that passage, or by inserting into it reeds, straw stems, quills, or tubes of paper filled with gunpowder. This is exploded by a long match, which the workmen kindle, and then retire to a place of safety.

As the *piercer* must not only be slender, but stiff, so as to be easily withdrawn when the hole is tamped, iron spindles are usually employed, though they occasionally give rise to sparks, and consequently to dangerous accidents, by their friction against the sides of the hole. Brass piercers have been sometimes tried; but they twist and break too readily.

Each hole bored in a mine, should be so placed in reference to the schistose structure of the rock, and to its natural fissures, as to attack and blow up the least resisting masses. Sometimes the rock is prepared beforehand for splitting in a certain direction, by means of a narrow channel excavated with the small hammer.

The quantity of gunpowder should be proportional to the depth of the hole, and the resistance of the rock, and merely sufficient to split it. Anything additional would serve no other purpose than to throw the fragments about the mine, without increasing the useful effect. Into the holes of about an inch and a quarter diameter, and 18 inches deep, only two ounces of gunpowder are put.

It appears that the effect of the gunpowder may be augmented by leaving an empty space above, in the middle of, or beneath the cartridge. In the mines of Silesia, the consumption of gunpowder has been eventually reduced, without diminishing the product of the blasts, by mixing sawdust with it, in certain proportions. The hole has also been filled up with sand in some cases, according to Mr. Jessop's plan, instead of being packed with stones, which has removed the danger of the tamping operation. The experiments made in this way have given results very advantageous in quarry blasts with great charges of gunpowder; but less favorable in the small charges employed in mines.

Water does not oppose an insurmountable obstacle to the employment of gunpowder; but when the hole cannot be made dry, a cartridge bag impermeable to water must be had recourse to, provided with a tube also impermeable, in which the *piercer* is placed.

After the explosion of each mining charge, wedges and levers are employed, to drag away and break down what has been shattered.

Wherever the rock is tolerably hard, the use of gunpowder is more economical and more rapid than any tool-work, and is therefore always preferred. A gallery, for example, a yard and a half high, and a yard wide, the piercing of which by the hammer formerly cost from five to ten pounds sterling the running yard, in Germany, is executed at the present day by gunpowder at from two to three pounds. When, however, a precious mass of ore is to be detached, when the rock is cavernous, which nearly nullifies the action of gunpowder, or when there is reason to apprehend that the shock caused by the explosion may produce an injurious fall of rubbish, hand-tools alone must be employed.

In certain rocks and ores of extreme hardness, the use both of tools and gunpowder becomes very tedious and costly. Examples to this effect are seen, in the mass of quartz mingled with copper pyrites, worked at Rammelsberg, in the Hartz, in the masses of stanniferous granite of Geyer and Altenberg in the Erzgebirge of Saxony, &c. In these circumstances, fortunately very rare, the action of fire is used with advantage to diminish the cohesion of the rocks and the ores. The employment of this agent is not necessarily restricted to these difficult cases. It was formerly applied very often to the working of hard substances; but the introduction of gunpowder into the mining art, and the increase in the price of wood, occasion fire to be little used as an ordinary means of excavation, except in places where the scantiness of the poulation has great extent of forest timber, as happens at Kongsberg in Norway, at Dannemora eden, at Felsobanya in Transylvania, &c.

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[*] Sir Rose Price invented a cap of bronze alloy, to tip the lower end of the iron rod; a contrivance now generally used in Cornwall. Before the Geological Society of that county introduced this invention into practice, scarcely a month elapsed without some dreadful explosion sending the miner to an untimely grave, or so injuring him by blowing out his eyes, or shattering his limbs, as to render him a miserable object of charity for the rest of his days. Scarcely has any accident happened since the employment of the new tamping-bar. When the whole bar was made of the tin and copper alloy it was expensive, and apt to bend: but the iron rod tipped with the bronze is both cheap and effectual. An ingenious instrument, called the shifting cartridge, was invented by Mr Chinalls, and is described in the Transactions of the above society.

e action of fire may be applied to the piercing of a gallery, or to the advancement horizontal cut, or to the crumbling down of a mass of ore, by the successive ing of the roof of a gallery already pierced. In any of these cases, the process ts in forming bonfires, the flame of which is made to play upon the parts to be ted. All the workmen must be removed from the mine, during, and even for time after, the combustion. When the excavations have become sufficiently cool w them to enter, they break down with levers and wedges, or even by means of wder, the masses which have been rent and altered by the fire.

complete our account of the manner in which man may penetrate into the interior e earth, we must point out the form of the excavations that he should make in it.

mines, three principal species of excavations may be distinguished; viz., *shafts*, *ies*, and the *cavities* of greater or less magnitude which remain in the room of the orkings.

haft or *pit* is a prismatic or cylindrical hollow space, the axis of which is either al or much inclined to the horizon. The dimension of the pit, which is never less 12 inches in its narrowest diameter, amounts sometimes to several yards. Its depth xtend to 1000 feet, and more. Whenever a shaft is opened, means must be pro- to extract the rubbish which continually tends to accumulate at its bottom, as well e waters which may percolate down into it; as also to facilitate the descent and t of the workmen. For some time a wheel and axle erected over the mouth of the ng, which serve to elevate one or two buckets of proper dimensions, may be suffi- for most of these purposes. But such a machine becomes ere long inadequate. -whims, or powerful steam-engines, must then be had recourse to; and effectual ds of support must be employed to prevent the sides of the shaft from crumbling lling down.

allery is a prismatic space, the straight or winding axis of which does not usually e much from the horizontal line. Two principal species are distinguished; the *ies* of *elongation*, which follow the direction of a bed or a vein; and the *transverse* ies, which intersect this direction under an angle not much different from 90°. most ordinary dimensions of galleries are a yard wide, and two yards high; but still larger may be seen traversing thick deposites of ore. There are few whose is less than 24 inches, and height less than 40; such small drifts serve merely as rary expedients in workings. Some galleries are several leagues in length. We describe in the sequel the means which are for the most part necessary to support oof and the walls. The rubbish is removed by wagons or wheelbarrows of s kinds. See *fig.* 712.

s impossible to advance the boring of a shaft or gallery beyond a certain rate, because t limited set of workmen can be made to bear upon it. There are some galleries t have taken more than 30 years to perforate. The only expedient for accelerating lvance of a gallery, is to commence, at several points of the line to be pursued, ms of galleries which may be joined together on their completion.

ether tools or gunpowder be used in making the excavations, they should be so d as to render the labor as easy and quick as possible, by disengaging the mass the rock at two or three of its faces. The effect of gunpowder, wedges, or picks, n much more powerful. The greater the excavation, the more important is it to re this rule. With this intent, the working is disposed in the form of *steps*, *ins*), placed like those of a stair; each step being removed in successive portions, hole of which, except the last, are disengaged on three sides, at the instant of their attacked.

e substances to be mined occur in the bosom of the earth, under the form of al deposites, beds, pipe-veins, or masses, threads or small veins, and rake-veins.

en the existence of a deposite of ore is merely suspected, without positive proofs, rse must be had to labors of research, in order to ascertain the richness, nature, isposition of a supposed mine. These are divided into three kinds; *open workings*, *ranean workings*, and *boring operations*.

The *working by an open trench*, has for its object to discover the outcropping or t edges of strata or veins. It consists in opening a fosse of greater or less width, , after removing the vegetable mould, the alluvial deposites, and the matters dis- ated by the atmosphere, discloses the native rocks, and enables us to distinguish ds which are interposed, as well as the veins that traverse them. The trench ought s to be opened in a direction perpendicular to the line of the supposed deposite. mode of investigation costs little, but it seldom gives much insight. It is chiefly yed for verifying the existence of a supposed bed or vein.

e *subterranean workings* afford much more satisfactory knowledge. They are ted by different kinds of perforations; viz., by *longitudinal galleries* hollowed out of the mass of the beds or veins themselves, in following their course; by *transverse galleries*, pushed at right angles to the direction of the veins; by *inclined shafts*, which pursue the slope of the deposites, and are excavated in their mass; or, lastly, by *perpendicular pits*.

If a vein or bed unveils itself on the flank of a mountain, it may be explored, according to the greater or less slope of its inclination, either by a longitudinal gallery opened in its mass, from the outcropping surface, or by a transverse gallery falling upon it in a certain point, from which either an oblong gallery or a sloping shaft may be opened.

If our object be to reconnoitre a highly inclined stratum, or a vein in a level country, we shall obtain it with sufficient precision, by means of shafts, 8 or 10 yards deep, dug at 30 yards distance from one another; excavated in the mass of ore, in the direction of its deposite. If the bed is not very much inclined, only 45°, for example, vertical shafts must be opened in the direction of its roof, or of the superjacent rocky stratum, and galleries must be driven from the points in which they meet the ore, in the line of its direction.

When the rocks which cover valuable minerals are not of very great hardness, as happens generally with the coal formation, with pyritous and aluminous slates, sal gem, and some other minerals of the secondary strata, the *borer* is employed with advantage to ascertain their nature. This mode of investigation is economi[illegible], and gives, in such cases, a tolerably exact insight into the riches of the interior. [illegible] method of using the borer has been described under Artesian Wells.

OF MINING IN PARTICULAR.

The mode of working mines is two-fold; by *open excavations*, and *subterranean*.

Workings in the open air present few difficulties, and occasion little expense, unless when pushed to a great depth. They are always preferred for working deposites little distant from the surface; where, in fact, other methods cannot be resorted to, if the substance to be raised be covered with incoherent matters. The only rules to be observed are, to arrange the workings in terraces, so as to facilitate the cutting down of the earth; to transport the ores and the rubbish to their destination at the least possible expense; and to guard against the crumbling down of the sides. With the latter view, they ought to have a suitable slope, or to be propped by timbers whenever they are not quite solid.

Open workings are employed for valuble clays, sands, as also for the alluvial soils of diamonds, gold, and oxyde of tin, bog iron ores, &c., limestones, gypsums, building stones, roofing slates, masses of rock salt in some situations, and certain deposites of ores, particularly the specular iron of the island of Elba; the masses of stanniferous granite of *Gayer*, *Altenberg*, and *Seyffen*, in the Ertzgeberge, a chain of mountains between Saxony and Bohemia; the thick veins or masses of black oxyde of iron of Nordmarch, Dannemora, &c., in Sweden; the mass of cupreous pyrites of Ræraas, near Drontheim in Norway; several mines of iron, copper, and gold in the Ural mountains, &c.

Subterranean workings may be conveniently divided into five classes, viz.:—

1. Veins, or beds, much inclined to the horizon, having a thickness of at least two yards.
2. Beds of slight inclination, or nearly horizontal, the power or thickness of which does not exceed two yards.
3. Beds of great thickness, but slightly inclined.
4. Veins, or beds highly inclined, of great thickness.
5. Masses of considerable magnitude in all their dimensions.

Subterranean mining requires two very distinct classes of workings; the *preparatory*, and those for *extraction*.

The *preparatory* consist in galleries, or in pits and galleries destined to conduct the miner to the point most proper for attacking the deposite of ore, for tracing it all round this point, for preparing chambers of excavation, and for concerting measures with a view to the circulation of air, the discharge of waters, and the transport of the extracted minerals.

If the vein or bed in question be placed in a mountain, and if its direction forms a very obtuse angle with the line of the slope, the miner begins by opening in its side, at the lowest possible level, a gallery of elongation, which serves at once to give issue to the waters, to explore the deposite through a considerable extent, and then to follow it in another direction; but to commence the real mining operations, he pierces either shafts or galleries, according to the slope of the deposite, across the first gallery.

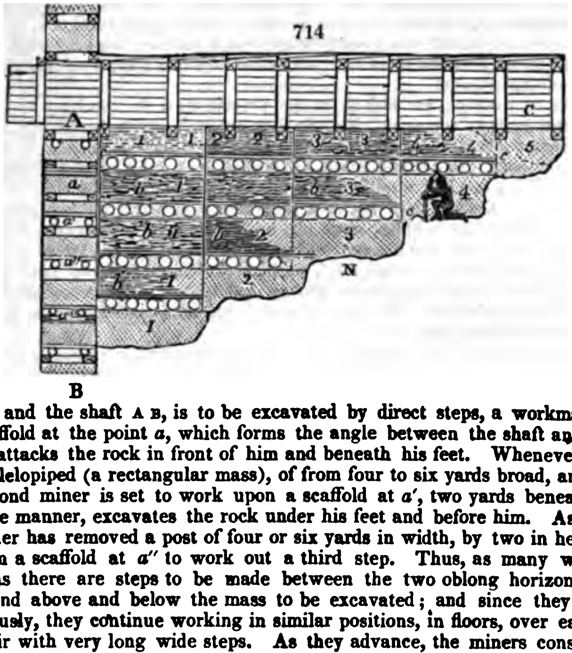
For a stratum little inclined to the horizon, placed beneath a plain, the first thing is to pierce two vertical shafts, which are usually made to arrive at two points in the same line of slope, and a gallery is driven to unite them. It is, in the first place, for the sake of circulation of air that these two pits are sunk; one of them, which is also destined for the drainage of the waters, should reach the lowest point of the intended workings.

If a vein is intersected by transverse ones, the shafts are placed so as to follow, or, at least, to cut through the intersections. When the mineral ores lie in nearly vertical masses, it is right to avoid, as far as possible, sinking pits into their interior. These should rather be perforated at one side of their floor, even at some considerable distance, to avoid all risk of crumbling the ores into a heap of rubbish, and overwhelming the workmen.

With a vein of less than two yards thick, as soon as the preparatory labors have brought the miners to the point of the vein from which the ulterior workings are to ramify, whenever a circulation of air has been secured, and an outlet to the water and the matters mined, the first object is to divide the mass of ore into large parallelopipeds, by means of oblong galleries, pierced 20 or 25 yards below one another, with pits of communication opened up, 30, 40, or 50 yards asunder, which follow the slope of the vein. These galleries and shafts are usually of the same breadth as the vein, unless when it is very narrow, in which case it is requisite to cut out a portion of the roof or the floor. Such workings serve at once the purposes of mining, by affording a portion of ore, and the complete investigation of the nature and riches of the vein, a certain extent of which is thus prepared before removing the cubical masses. It is proper to advance first of all, in this manner, to the greatest distance from the central point which can be mined with economy, and afterwards to remove the parallelopiped blocks, in working back to that point.

This latter operation may be carried on in two different ways; of which one consists in attacking the ore from above, and another from below. In either case, the excavations are disposed in steps similar to a stair upon their upper or under side. The first is styled a *working* in direct or descending steps; and the second a *working* in *reverse*, or ascending steps.

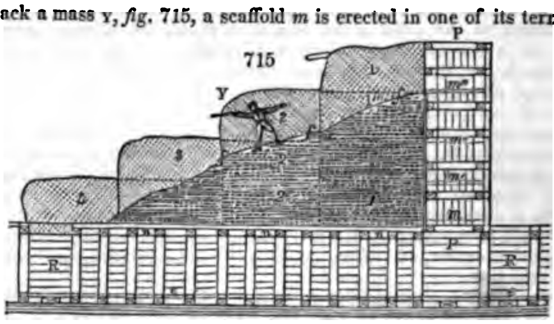
1. Suppose, for example, that the post N, *fig.* 714, included between the horizontal



gallery A C and the shaft A B, is to be excavated by direct steps, a workman stationed upon a scaffold at the point a, which forms the angle between the shaft and the elongated drift, attacks the rock in front of him and beneath his feet. Whenever he has cut out a parallelopiped (a rectangular mass), of from four to six yards broad, and two yards high, a second miner is set to work upon a scaffold at a', two yards beneath the first, who, in like manner, excavates the rock under his feet and before him. As soon as the second miner has removed a post of four or six yards in width, by two in height, a third begins upon a scaffold at a'' to work out a third step. Thus, as many workmen are employed as there are steps to be made between the two oblong horizontal galleries which extend above and below the mass to be excavated; and since they all proceed simultaneously, they continue working in similar positions, in floors, over each other, as upon a stair with very long wide steps. As they advance, the miners construct before them wooden floors *c c c c*, for the purpose of supporting the rubbish which each workman extracts from his own step. This floor, which should be very solid, serves also for wheeling out his barrow filled with ore. The round billets which support the planks sustain the roof or the wall of the mineral vein or bed under operation. If the rubbish be very considerable, as is commonly the case, the floor planks are lost. However strongly they may be made, as they cannot be repaired, they sooner or later give way under the enormous pressure of the rubbish; and as all the weight is borne by the roof of the oblong gallery underneath, this must be sufficiently timbered. By this ingenious plan, a great many miners may go to work together upon a vein without mutual interference; as the portions which they detach have always two faces at least free, they are consequently more easily separable, either with gunpowder or with the pick. Should the vein be more than a yard thick, or if its substance be very refractory, two miners are set upon each step. *b b b b* indicate the quadrangular masses that are cut out successively downwards; and 1 1, 2 2, 3 3, forwards; the lines of small circles are the sections of the ends of the billets which support the floors.

2. To attack a mass Y, *fig.* 715, a scaffold *m* is erected in one of its terminal pits P P, at the level of the ceiling of the gallery R R′, where it terminates below. A miner placed on this scaffold, cuts off at the angle of this mass a parallelopiped 1, from one to two yards high, by six or eight long. When he has advanced thus far, there is placed in the same pit, upon another scaffold *m′*, a second miner, who attacks the vein above the roof of the first cutting, and hews down, above the parallelopiped 1, a parallelopiped of the same dimensions 1′, while the first is taking out another 2, in advance of 1. When the second miner has gone forward 6 or 8 yards, a third is placed also in the same pit. He commences the third step, while the first two miners are pushing forwards theirs, and so in succession.

715



In this mode of working, as well as in the preceding, it is requisite to support the rubbish and the walls of the vein. For the first object, a single floor N N N, may be sufficient, constructed above the lower gallery, substantial enough to bear all the rubbish, as well as the miners. In certain cases, an arched roof may be substituted; and in others, several floors are laid at different heights. The sides of the vein are supported by means of pieces of wood fixed between them perpendicularly to their planes. Sometimes, in the middle of the rubbish, small pits are left at regular distances apart, through which the workmen throw the ore coarsely picked, down into the lower gallery. The rubbish occasionally forms a slope *f f f*, so high that miners placed upon it can work conveniently. When the rich portions are so abundant as to leave too little rubbish to make such a sloping platform, the miners plant themselves upon moveable floors, which they carry forward along with the excavations.

These two modes of working in the *step-form*, have peculiar advantages and disadvantages; and each is preferred to the other according to circumstances.

In the *descending workings*, or in *direct steps*, *fig.* 714, the miner is placed on the very mass or substance of the vein; he works commodiously before him; he is not exposed to the splinters which may fly off from the roof; but by this plan he is obliged to employ a great deal of timber to sustain the rubbish; and the wood is fixed for ever.

In the *ascending workings*, or in *reversed steps*, *fig.* 715, the miner is compelled to work in the re-entering angle formed between the roof and the front wall of his excavation, a posture sometimes oppressive; but the weight of the ore conspires with his efforts to make it fall. He employs less timber than in the *workings* with *direct steps*. The *sorting* of the ore is more difficult than in the *descending working*, because the rich ore is sometimes confounded with the heap of rubbish on which it falls.

When seams of diluvium or gravel-mud occur on one of the sides of the vein, or on both, they render the quarrying of the ore more easy, by affording the means of uncovering the mass to be cut down, upon an additional face.

Should the vein be very narrow, it is necessary to remove a portion of the sterile rock which encloses it, in order to give the work a sufficient width to enable the miner to advance. If, in this case, the vein be quite distinct from the rock, the labor may be facilitated, as well as the separation of the ore, by disengaging the vein, on one of its faces, through a certain extent, the rock being attacked separately. This operation is called *stripping the vein*. When it is thus uncovered, a shot of gunpowder is sufficient to detach a great mass of it, unmixed with sterile stones.

By the methods now described, only those parallelopipeds are cut out, either in whole or in part, which present indications of richness adequate to yield a prospect of benefit. In other cases, it is enough to follow out the threads of ore which occur, by workings made in their direction.

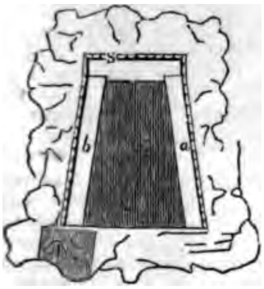
The miner, in searching within the crust of the earth for the riches which it conceals, is exposed to many dangers. The rocks amidst which he digs are seldom or never entire, but are almost always traversed by clefts in various directions, so that impending fragments threaten to fall and crush him at every instant. He is even obliged at times to cut through rotten friable rocks or alluvial loams. Fresh atmospheric air follows him with difficulty in the narrow channels which he lays open before him; and the waters which circulate in the subterranean seams and fissures filter incessantly into his excavation, and tend to fill it. Let us now take a view of the means he employs to escape from these three classes of dangers.

1. *Of the timbering of excavations.*—The excavations of mines are divisible into three principal species; *shafts*, *galleries*, and *chambers*. When the width of these excavations is inconsiderable, as is commonly the case with shafts and galleries, their sides can sometimes stand upright of themselves; but more frequently they require to be propped or stayed by billets of wood, or by walls built with bricks or stones; or even by stuffing the space with rubbish. These three kinds of *support* are called *timbering*, *walling*, and *filling up*.

Timbering is most used. It varies in form for the three species of excavations, according to the solidity of the walls which it is destined to sustain.

In a gallery, for example, it may be sufficient to support merely the roof, by means of joists placed across, bearing at their two ends in the rock; or the roof and the two walls by means of an upper joist s, *fig.* 716, which is then called a *cap* or *cornice beam*, resting on two lateral upright posts or *stanchions*, *a b*, to which a slight inclination towards each other is given, so that they approach a little at the top, and rest entirely upon the floor. At times, only one of the walls and the roof need support. This case is of frequent occurrence in pipe veins. Pillars are then set up only on one side, and on the other the joists rest in holes of the rock. It may happen that the floor of the gallery shall not be sufficiently firm to afford a sure foundation to the standards; and it may be necessary to make them rest on a horizontal piece called the *sole*. This is timbering with *complete frames*. The upright posts are usually set directly on the sole; but the extremities of the *cap* or ceiling, and the upper ends of the *standards*, are mortised in such a manner that these cannot come nearer, whereby the cap shall possess its whole force of resistance. In friable and shivery rocks there is put behind these beams, both upon the ceiling and the sides, *facing boards*, which are planks placed horizontally, or spars of cleft wood, set so close together as to leave no interval. They are called *fascines* in French. In ordinary ground, the miner puts up these *planks* in proportion as he goes forwards; but in a loose soil, such as sand or gravel, he must mount them a little in advance. He then drives into the mass behind the wooden frame-work, thick but sharp-pointed planks or stakes, and which, in fact, form the sides of the cavity, which he proceeds to excavate. Their one extremity is thus supported by the earth in which it is thrust, and their other end by the last framing. Whenever the miner gets sufficiently on, he sustains the walls by a new frame. The size of the timber, as well as the distance between the frames or *stanchions*, depends on the degree of pressure to be resisted.

716.



When a gallery is to serve at once for several distinct purposes, a greater height is given to it; and a flooring is laid on it at a certain level. If, for example, a gallery is to be employed, both for the transport of the ores and the discharge of the waters, a floor *e e*, *fig.* 715, is constructed above the bottom, over which the carriages are wheeled, and under which the waters are discharged.

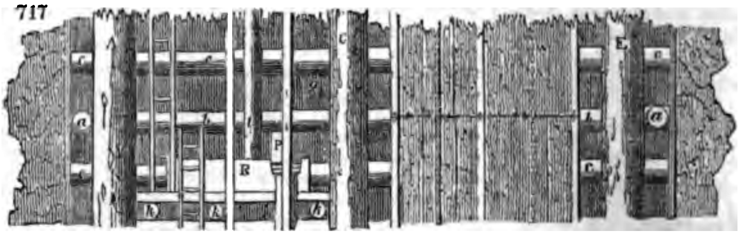
The timbering of shafts varies in form, as well as that of galleries, according to the nature and the locality of the ground which they traverse, and the purposes which they are meant to serve. The shafts intended to be stayed with timber are usually square or rectangular, because this form, in itself more convenient for the miner, renders the execution of the timbering more easy. The wood-work consists generally of rectangular frames, the spars of which are about eight inches in diameter, and placed at a distance asunder of from a yard to a yard and a half. The spars are never placed in contact, except when the pressure of the earth and the waters is very great. The pieces composing the frames are commonly united by a half-check, and the longer of the two pieces extends often beyond the angles, to be rested in the rock. Whether the shaft is vertical or inclined, the frame-work is always placed so that its plane may be perpendicular to the axis of the pit. It happens sometimes in inclined shafts that there are only two sides, or even a single one, which needs to be propped. These are stayed by means of cross beams, which rest at their two ends in the rock. When the frames do not touch one another, strong planks or stakes are fastened behind them to sustain the ground. To these planks the frames are firmly connected, so that they cannot slide. In this case the whole timbering will be supported, when the lower frame is solidly fixed, or when the pieces from above pass by its angles to be abutted upon the ground.

In the large rectangular shafts, which serve at once for extracting the ores, for the discharge of the waters, and the descent of the workmen, the spaces destined for these several purposes are in general separated by partitions, which also serve to increase the strength of the timberings, by acting as buttresses to the planks in the long sides of the frame-work. Occasionally a partition separates the ascending from the descending basket, to prevent their jostling.—Lastly, particular passages are left for ventillation.

As it is desirable that the wood shall retain its whole force, only those pieces are squared which absolutely require it. The spars of the frames in shafts and galleries are deprived merely of their bark, which by holding moisture, would accelerate the decomposition of the wood. The alburnum of oak is also removed.

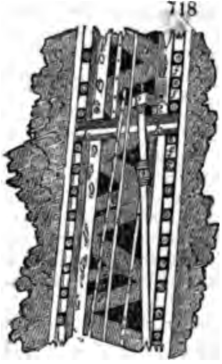
Resinous woods, like the pine, last much shorter than the oak, the beech, and the cherry-tree; though the larch is used with advantage. The oak has been known to last upwards of 40 years; while the resinous woods decay frequently in 10. The fresher the air in mines, the more durable is the timbering.

717



The marginal *figs*. 717, 718 represent two vertical sections of a shaft, the one at right angles to the other, with the view of showing the mode of sustaining the walls of the excavation by timbering. It is copied from an actual mine in the Hartz. There we may observe the spaces allotted to the descent of the miners by ladders, to the drainage of the waters by pumps P, and rods *t*, and to the extraction of the mineral substances by the baskets B. *a*, *b*, *c*, *f*, *h*, *k*, various cross timbers; A, C, E, upright do.; R, pump cistern; V, W, corve-ways. The shafts here shown, are excavated in the line of the vein itself,—the rock enclosing it being seen in the second figure.

718



In a great many mines it is found advantageous to support the excavations by brick or stone buildings, constructed either with or without mortar. These constructions are often more costly than wooden ones, but they last much longer, and need fewer repairs. They are employed instead of timberings, to support the walls and roof of galleries, to line the sides of shafts, and to bear up the roofs of excavations.

Sometimes the two sides of a gallery are lined with vertical walls, and its roof is supported by an ogee vault, or an arch. If the sides of the mine are solid, a simple arch is sufficient to sustain the roof, and at other times the whole surface of a gallery is formed of a single elliptic vault, the great axis of which is vertical; and the bottom is surmounted by a wooden plank, under which the waters run off; see *fig*. 719.

Walled shafts also are sometimes constructed in a circular or elliptic form, which is better adapted to resist the pressure of the earth and waters. Rectangular shafts of all dimensions, however, are frequently walled.

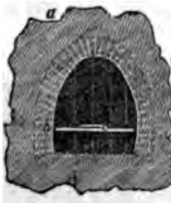
The sides of an excavation may also be supported by filling it completely with rubbish. Wherever the sides need to be supported for some time without the necessity of passing along them, it is often more economical to stuff them up with rubbish, than to keep up their supports. In the territory of Liege, for example, there have been shafts thus filled up for several centuries; and which are found to be quite entire when they are emptied. The rubbish is also useful for forming roads among steep strata, for closing air-holes, and forming canals of ventilation.

Figs. 719, 720, 721 represent the principal kinds of mason-work employed in the galleries and shafts of mines. *Fig*. 722 exhibits the walling in of the cage of an overshot water wheel, as mounted within a mine. Before beginning to build, an excavation large enough must be made in the gallery to leave a space three feet and a half high for the workmen to stand in, after the brick-work is completed. Between the two opposite sides, cross beams of wood must be fixed at certain distances, as chords of the vault, over which the rock must be hollowed out to receive the arch-stones, and the centring must then be placed, covered with deals to receive the *voussoirs*, beginning at the flanks and ending with the key-stone. When the vault is finished through a certain extent, the interval between the arch and the rock must be rammed full of rubbish, leaving passages, if necessary, through it and the arch, for currents of water.

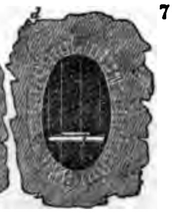
In walling galleries, attention must be paid to the direction of the pressure, and to build vertically or with a slope accordingly. Should the pressure be equal in all directions, a closed vault, like *fig.* 719, should be formed. For walls not far from the vertical, salient or buttressed arches are employed, as shown in *fig.* 720, called in German *überspringende bogen;* for other cases, twin-arches are preferred, with an upright wall between.

Fig. 721 is a transverse section of a walled drain-gallery, from the grand gallery of the Hartz; see also *fig.* 722. *a* is the rock, which needs to be supported only at the sides and top; *b*, the masonwork, a curve formed of the three circular arcs upon one level; *c*, the floor for the water-course. *Fig.* 719 is a cross section of a walled gallery, as at Schneeberg, Rothenburg, Idria, &c.; *d*, is the rock, which is not solid either at the flanks, roof, or floor; *e*, the elliptic masonwork; *f*, the wooden floor for the wagons, which is sometimes, however, arched in brick to allow of a water-course beneath it.

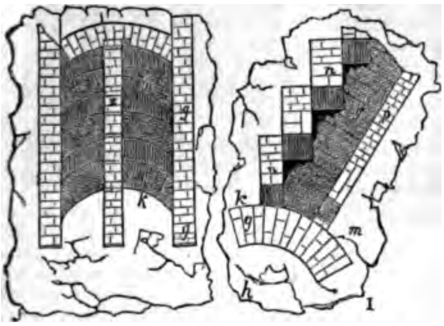
721



719



720



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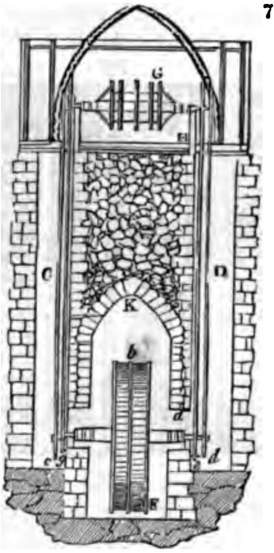


Fig. 720 shows two vertical projections of a portion of a walled shaft with buttresses, as built at the mine *Vater Abraham*, near Marienberg. J is a section in the direction of the vein *g h*, to show the roof of the shaft. I, a section exhibiting the slope of the vein *g h*, into which the shaft is sunk; *m* is the wall of the vein; *k* is the roof of the same vein; *n*, buttresses resting upon the flanks of the shaft; *g*, great arcs on which the buttresses bear; *y*, vertical masonwork; *z*, a wall which divides the shaft into two compartments, of which the larger, *p*, is that for extracting the ore, and the smaller for the draining and descent of the miners.

Fig. 722, C D is the shaft in which the vertical crank-rods *c g*, *e d*, move up and down. F, is a double hydraulic wheel, which can be stopped at pleasure by a brake mounted upon the machine of extraction. G, is the drum of the gig or whim for raising the *corves* or tubs (*tonnes*); H, is the level of the ground, with the carpentry which supports the whim and its roof. *k*, is the key-stone of the *ogee* arch which covers the water-wheel; *a*, is the opening or window, traversed by the extremity of the driving shaft, upon each side of the water-wheel, through which a workman may enter to adjust or repair it; *i b*, line of conduits for the streams of water which fall upon the hydraulic wheel; *c*, *g*, double crank with rods, whose motion is taken off the left side of the wheel; *e*, *d*, the same upon the right side. The distance from H to F is about 22 yards.

Figs. 723, 724 present two vertical sections of the shaft of a mine walled, like the roof of a cavern, communicating with the galleries of the roof and the wall of the vein, and well arranged for both the extraction of the ore, and the descent of the miners. The vertical partition of the shaft for separating the passage for the corves or tubs from the ladders is omitted in the figure, for the sake of clearness.

In *fig.* 723, A, B are the side walls supported upon the buttresses C and D; in *fig.* 724, E is the masonry of the wall, borne upon the arch F at the entrance to a gallery; the continuation being at G, which is sustained by a similar arch built lower.

L, is the vault arch of the roof, supported upon another vault M, which presents a double curvature, at the entrance of a gallery; at H is the continuation of the arch or vault L, which underneath is supported in like manner at the entrance of a lower gallery.

a b, *c d*, *fig.* 723, are small upright guide-bars or rods for one of the corves, or kibbles.

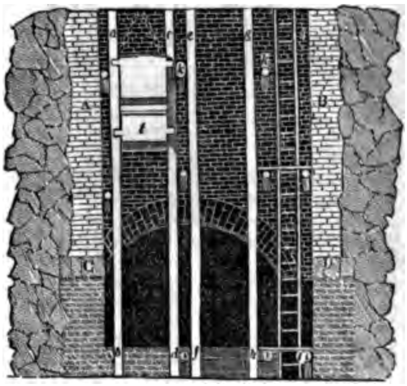
e f, *g h*, are similar guide-bars for the other corf.

i i, are cross-bars of wood, which support the stays of the ladders of descent.

k k, are also cross-bars by which the guide-rods are secured.

t, a *corf*, or extraction kibble, furnished with friction rollers; the other corf is supposed to be drawn up to a higher level, in the other vertical passage.

723



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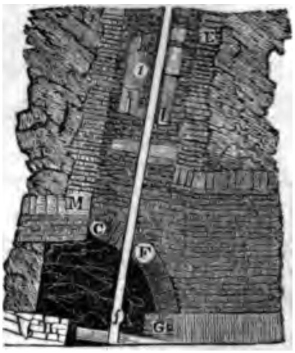

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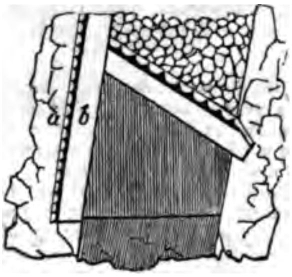

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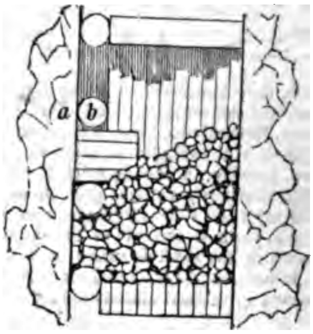
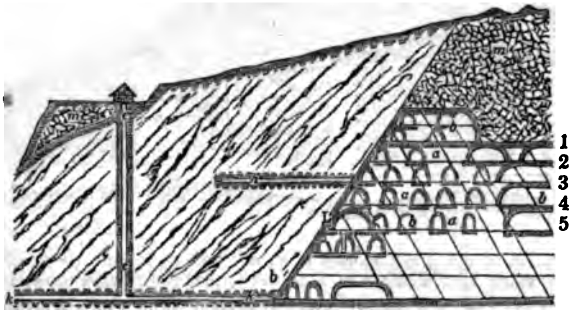


Figs. 725, 726 represent in a vertical section the mode of timbering the galleries of the silver and lead mines at Andreasberg in the Hartz. *Fig.* 725 shows the plan viewed from above. Upon the roof of the timbering, the workman throws the waste rubbish, and in the empty space below, which is shaded black, he transports in his wagons or wheelbarrows the ores towards the mouth of the mine. *Fig.* 726 is the cross section of the gallery. In the two figures, *a* represents the rock, and *b* the timbering; round which there is a garniture of small spars or laths for the purpose of drainage and ventilation, with the view of promoting the durability of the wood-work.

The working of minerals by the *mass* is well exemplified a few leagues to the north of Siegen, near the village of Müsen, in a mine of iron and other metals, called *Stahlberg*, which forms the main wealth of the country. The plan of working is termed *the excavation of a direct or transverse mass*. It shows in its upper part the danger of bad mining, and in its inferior portion, the regular workings, by whose means art has eventually prevented the destruction of a precious mineral deposite.

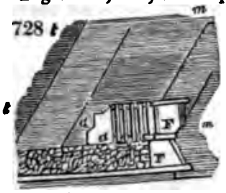
Fig. 727 is a vertical section of the bed of ore, which is a *direct* mass of spathose

727



iron, contained in transition rock (graywacke). *a*, *a*, *a*, are pillars of the sparry ore, reserved to support the successive stages or floors, which are numbered 1, 2, 3, &c.; *b*, *b*, *b*, are excavations worked in the ore; which exhibit at the present day several floors of arches, of greater or less magnitude, according to the localities. It may be remarked, that where the metallic deposite forms one entire mass, rich in spathose iron ore of good quality, there is generally given to the vaults a height of three fathoms; leaving a thickness over the roof of two fathoms, on account of the numerous fissures which pervade the mass. But where this mass is divided into three principal branches, the roof of the vaults has only a fathom and a half of thickness, while the excavation is three fathoms and a half high. In the actual state of the workings, it may be estimated that from all this direct mass, there is obtained no more out of every floor than one third of the mineral. Two thirds remain as labors of reserve, which may be resumed at some future day, in consequence of the regularity and the continuation of the subterranean workings. *e* is a shaft for extraction, communicating below with the gallery of efflux *k*; *h* is an upper gallery of drainage, which runs in different directions (one only being visible in this section) over a length of 400 fathoms. The lower gallery *k* runs 646 fathoms in a straight line. The mine of Stahlberg has furnished annually on an average since 1760 about 25,000 cubic feet (French) of an excellent spathose ore of iron. *m m*, represents the mass of sparry iron.

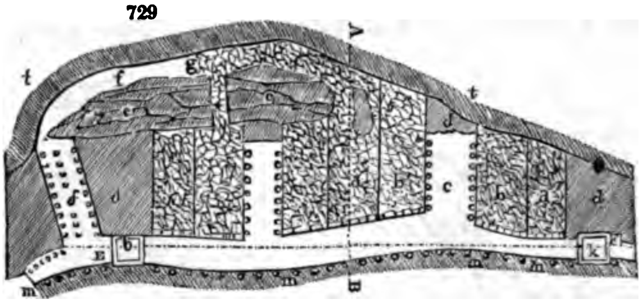
728



Figs. 728, 729, 730 represent the cross system of mining, which consists in forming galleries through a mineral deposite, from its wall or floor towards its roof, and not, as usual, in the direction of its length. This mode was contrived towards the middle of the 18th century, for working the very thick veins of the Schemnitz mine in Hungary, and it is now employed with advantage in many places, particularly at Idria in Carniola. In the two sections *figs.* 728, 730, as well as in the ground plan *fig.* 729, the wall is denoted by *m m*, and the roof by *t t*. A first gallery of prolongation E F, *fig.* 730, being formed to the wall, transverse cuts, *a a*, are next established at right angles to this gallery, so that between every two there may be room enough to place three others, *b*, *c*, *b*, *fig.* 729. From each of the cuts *a*, ore is procured by advancing with the help of timbering, till the roof *t* be reached. When this is done, these first cuts *a*, are filled up with rubbish, laid upon pieces of timber with which the ground is covered, so that if eventually it should be wished to mine underneath, no downfall of detritus is to be feared. These heaps of rubbish rise only to within a few inches of the top of the cuts *a*, in order that the working of the upper story may be easier, the bed of ore being there already laid open upon its lower face.

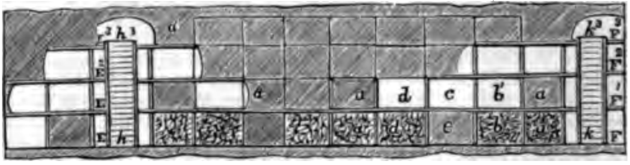
In proportion as the cuts *a*, of the first story E F, are thus filled up, the greater part of the timbering is withdrawn, and made use of elsewhere. The intermediate cuts *b*, *c*, *b*, are next mined in like manner, either beginning with the cuts *c*, or the cuts *b*, according to the localities. From *fig.* 729 it appears that the working may be so arranged, that in case of necessity, there may be always between two cuts in activity the distance of three cuts, either not made, or filled up with rubbish. Hence, all the portion of the bed of ore may be removed, which corresponds to a first story E F, *fig*. 730, and this portion is replaced by rubbish.

729



The exploration of the upper stories E′ F′, E^2 F^2, E^3 F^3, is now prepared in a similar manner; with which view shafts *h* h^3, *k* k^3, are formed from below upwards in the wall *m* of the deposite, and from these shafts oblong galleries proceed, established successively on a level with the stories thus raised over one another. See *fig*. 730. The following objects may be specified in the figures:—

730



a a, the first cuts filled up with rubbish, upon the first story E F, *fig*. 729.

b b, other cuts subsequently filled up, upon the same story.

c, the cut actually working.

d, the front of the cut, or place of actual excavation of the mineral deposite.

e, masses of the barren rock, reserved in the cutting, as pillars of safety.

f, galleries, by means of which the workmen may turn round the mass *e*, in order to form, in the roof *t*, an excavation in the direction of the deposite.

g, rubbish behind the mass *e*.

k k, two shafts leading from the first story E F, to the upper stories of the workings, as already stated.

m, the wall, and *t* the roof of the mineral bed.

In the second story E′ F′, the gallery of prolongation F′, *figs*. 728 and 730, is not entirely perforated; but it is further advanced than that of the third story, which, in its turn, is more than the gallery of the fourth.

From this arrangement there is produced upon *fig*. 730 the general aspect of a working by reversed steps.

Whenever the workings of the cuts *c* in the first story are finished, those of the second, *a′ a′*, may be begun in the second; and thus by mounting from story to story, the whole deposite of ore may be taken out and replaced with rubbish. One great advantage of this method is, that nothing is lost; but it is not the only one. The facilities offered by the system of *cross workings* for disposing of the rubbish, most frequently a nuisance to the miner, and expensive to get rid of, the solidity which it procures by the banking up, the consequent economy of timbering, and saving of expense in the excavation of the rock, reckoning from the second story, are so many important circumstances which recommend this mode of mining. Sometimes, indeed, rubbish may be wanted to fill up, but this may always be procured by a few accessory perforations; it being easy to establish in the vicinity of the workings a vast excavation in the form of a vault, or kind of subterraneous quarry, which may be allowed to fall in with proper precautions, and where rubbish will thus accumulate in a short time, at little cost.

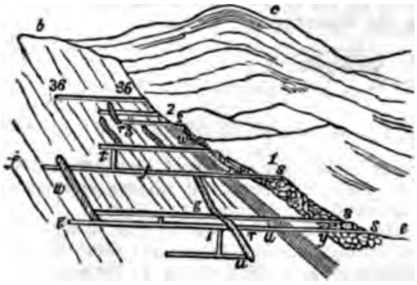
Fig. 731 represents a section of the celebrated lead mines of Bleyberg in Carinthia, not far from Villach.

b, c, is the ridge of the mountains of compact limestone, in whose bosom the workings are carried on.

e, is the metalliferous valley, running from east to west, between the two parallel valleys of the Gail and the Drave, but at a level considerably above the waters of these rivers.

f g is the direction of a great many vertical beds of metalliferous limestone.

731



On considering the direction and dip of the marly schist, and metalliferous limestone, in the space *w*, *w*, to the west of the line 1, *s*, it would appear that a great portion of this system of mountains has suffered a slip between 1, *s*, and a parallel one towards the east; whereby, probably, that vertical position of the strata has been produced, which exists through a considerable extent. The metalliferous limestone is covered to a certain thickness with a marly schist, and other more recent rocks. It is in this schist that the fine marble known under the name of the *lumachello of Bleyberg* is quarried.

The galena occurs in the bosom of this rock in flattened masses, or blocks of a considerable volume, which are not separated from the rest of the calcareous beds by any seam. It is accompanied by zinc ore (*calamine*), especially in the upper parts of the mountain.

Several of the workable masses are indicated by *r*, r^3; each presents itself as a solid analogous to a very elongated ellipse, whose axis dips, not according to the inclination of the surrounding rock, but to an oblique or intermediate line between this inclination, and the direction of the beds of limestone; as shown by *r w*, *r′ u*. Every thing indicates the contemporaneous formation of the limestone, and the lying beds of the lead ore.

The accidents or faults called *kluft* (*rent*) at Bleyberg are visible on the surface of the ground. Experienced miners have remarked that the rich masses occur more frequently in the direction of these accidents than elsewhere.

It is in general by galleries cut horizontally in the body of the mountain, and at different levels, *s*, *g*, *sf*, that the miner advances towards the masses of ore *r*, r^3. Many of these galleries are 500 fathoms long before they reach a workable mass. The several galleries are placed in communication by a few shafts, such as *t*; but few of these are sunk deeper than the level of the valley *e*.

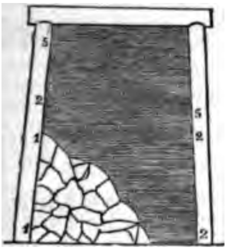
The total length of the mines of Bleyberg is about 10,000 yards, parallel to the valley *e*; in which space there are 500 concessions granted by the government to various individuals or joint stock societies, either by themselves or associated with the government.

The metalliferous valley contains 5000 inhabitants, all deriving subsistence from the mines; 300 of whom are occupied in the government works.

Each concession has a number and a name; as Antoni, Christoph, Matthæus, Oswaldi, 2, 8, 36, &c.

Fig. 732 is a section in the quicksilver mine of Idria. 1. is the gray limestone; 2. is a blackish slate; 5. is a grayish slate. Immediately above these transition rocks lies the bed containing the ores called *corallenerz*, which consist of an intimate mixture of sulphuret of mercury and argillaceous limestone; in which four men can cut out, in a month, 2¼ toises cube of rock.

732



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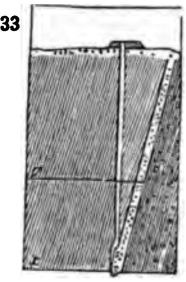


Fig. 733 represents a section of part of the copper mine of Mansfeldt; containing the cellular limestone, called *rauchwacke*, always with the compact marl-limestone called zechstein; the cupreous schist, or *kupferschiefer;* the wall of grayish-white sandstone, called the *weisse liegende;* and the wall of red sandstone, or the *rothelie gende*. The thin dotted stratum at top is vegetable mould; the large dotted portion to the right of the figure is oolite; the vein at its side is sand; next is *rauchwacke;* and lastly, the main body of fetid limestone, or *stinkstein*.

Fig. 734 represents one of the Mansfeldt copper schist mines in the district called Burgoerner, or Preusshoheit.

1. Vegetable mould, with silicious gravel.

2. Ferruginous clay or loam.

3. Sand, with fragments of quartz.

4. Red clay, a bed of variable thickness as well as the lower strata, according as the cupreous schist is nearer or farther from the surface.

5. Ooolite (*roogenstein*).

6. Newer variegated sandstone (*bunter sandstein*).

7. Newer gypsum; below which, there is

8. A bluish marly clay.

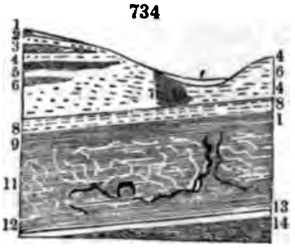
9. Stinkstone, or lucullite.

10. Friable grayish marl.

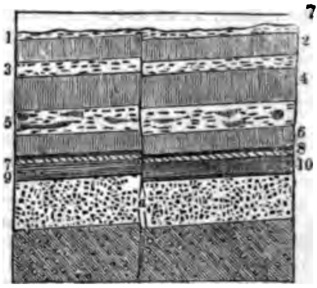
11. Older gypsum, a rock totally wanting in the other districts of the mines of Rothenberg; but abounding in Saxon Mansfeldt, where it includes vast caverns known among the miners by the name of *schlotten*, as indicated in the figure.

12. The calcareous rock called *zechstein*. The lower part of this stratum shows symptoms of the cupriferous schist that lies underneath. It presents three thin bands, differently modified, which the miner distinguishes as he descends by the names of the sterile or rotten (*faüle*) rock; the roof (*dachklotz*); and the main rock (*oberberg*.)

734



735



13. Is a bed of cupriferous schist (*kupferschiefer*), also called the *bitumino-marly* schist, in which may be noted, in going down, but not marked in the figure:—

a, the *lochberg*, a seam 4 inches thick.
b, the *kammschale*, ¼ of an inch thick.
c, the *kopfschale*, one inch thick.

These seams are not worth smelting; the following, however, are:—

d, the *schiefer kopf*, the main copper schist, 2 inches thick.
e, a layer called *lochen*, one inch thick.

14. The wall of sandstone, resting upon a porphyry.

Fig. 735 is a section of the mines of Kiegelsdorf in Hessia, presenting—

1. Vegetable mould.

2. Limestone distinctly stratified, frequently of a yellowish color, called *lagerhafter kalkstein*.

3. Clay, sometimes red, sometimes blue, sometimes a mixture of red, blue, and yellow.

4. The cellular limestone (*rauhkalk*). This rock differs both in nature and position from the rock of the same name at Mansfeldt.

5. Clay, usually red, containing veins of white gypsum, and fine crystals of selenite.

6. Massive gypsum of recent formation.

7. Fetid limestone, compact and blackish gray, or cellular and yellowish gray.

8. Pulverulent limestone, with solid fragments interspersed.

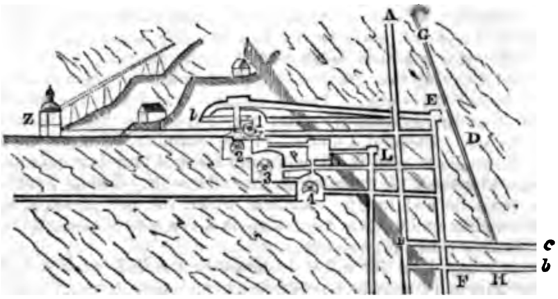
9. Compact marl-limestone, or *zechstein*, which changes from a brownish color above to a blackish schist below, as it comes nearer the cupreous schist, which seems to form a part of it.

10. Cupreous schist (*kupferschiefer*), of which the bottom portion, from 4 to 6 inches thick, is that selected for metallurgic operations. Beneath it, is found the usual wall or bed of sandstone. A vein of cobalt ore *a*, which is rich only in the grayish-white sandstone (*weisse liegende*), traverses and deranges all the beds wherever it comes.

Of working mines by fire.—The celebrated mine worked since the tenth century in the mountain called *Rammelsberg*, in the Hartz, to the south of Goslar, presents a stramass of ores, among the beds of the rock which constitute that mountain. The ral deposite is situated in the earth, like an enormous inverted wedge, so that its ness (power), inconsiderable near the surface of the ground, increases as it descends. bout 100 yards from its outcrop, reckoning in the direction of the slope of the de- e, it is divided into two portions or branches, which are separated from each other, ghout the whole known depth, by a mass of very hard clay slate, which passes into ' slate. The substances composing the workable mass are copper and iron pyrites sulphuret of lead (galena), accompanied by quartz, carbonate of lime, compact sul- : of baryta, and sometimes gray copper ore, sulphuret of zinc, and arsenical pyrites. ores of lead and copper contain silver and gold, but in small proportion, particularly the last.

mine so ancient as that of Rammelsberg, and which was formerly divided among al adventurous companies, cannot fail to present a great many shafts and excava- ; but out of the 15 pits, only two are employed for the present workings ; namely, marked A B and E F, in *fig.* 736, by which the whole extraction and drainage are

736



ted. The general system of exploitation by fire, as practised in this mine, consists e following operations :—

An advance is made towards the deposites of ore, successively at different levels, insverse galleries which proceed from the shaft of extraction, and terminate at the of the stratiform mass.

There is formed in the level to be worked, large vaults in the heart of the ore, by s of fire, as we shall presently describe.

The floor of these vaults is raised up by means of terraces formed from the rubbish, portion as the roof is scooped out.

The ores detached by the fire from their bed, are picked and gathered; sometimes irger blocks are blasted with gunpowder.

Lastly, the ores thus obtained are wheeled towards the shaft of extraction, and d out to the day.

t us now see how the excavation by fire is practised; and in that view, let us con- the state of the workings in the mines of Rammelsberg in 1809. We may remark '. 736 the regularity of the vaults previously scooped out above the level B C, and ther vaults which are in full activity of operation. It is, therefore, towards the ' levels that the new workings must be directed. For this purpose, the transverse y being already completed, there is prepared on the first of these floors a vault of itation at *b*, which eventually is to become similar to those of the superior levels. e same time, there is commenced at the starting point below it, reached by a small dug in the line of the mineral deposite, a transverse gallery in the rock, by means isting with gunpowder. The rock is also attacked at the starting-point by a similar which advances to meet the first perforation. In this way, whenever the vaults of vel c are exhausted of ore and terraced up with rubbish, those of the level beneath l be in full activity.

iers will then be prepared at a lower level; and the exploitation may afterwards be a below this level by pursuing the same plan, by which the actual depth of excava- as been gained.

workings by fire we must distinguish, 1. The case where it is neecessary to open ilt immediately from the floor; 2. The case where the vault having already a n elevation, it is necessary to heighten its roof. In the former case, the wall or floor : mineral deposite is first penetrated by blasting with gunpowder. As soon as this ration is effected over a certain length, parallel to the direction of the future , as happens at *b*, there is arranged on the bottom a horizontal layer of billets of d, over which other billets are piled in nearly a vertical position, which rest upon e, so that the flame in its expansion comes to play against the mineral mass to be detached. When after some similar operations, the flame of the pile can no longer reach the ore of the roof on account of its height, a small terrace of rubbish must be raised on the floor of the deposite; and over this terrace, a new pile of fagots is to be heaped up as above described. The ancient miners committed the fault of constantly placing such terraces close to the roof, and consequently arranging the fagots against this portion of the ore, so that the flame circulated from the roof down to the floor. The result of such procedure was the weakening of the roof, and the loss of much of the ore which could not be extracted from so unstable a fabric; and besides, much more wood was burned than at the present day, because the action of the flame was dissipated in part against the whole mass of the roof, instead of being concentred on the portion of the ore which it was desired to dislodge. Now, the flame is usually made to circulate from the floor to the roof, in commencing a new vault.

When the vault has already a certain height, care is always taken that between the roof of the vault and the rubbish on which the pile is arranged, no more than two yards of space should intervene, in order that the flame may embrace equally the whole concavity of the vault, and produce a uniform effect on all its parts. Here, the pile is formed of horizontal beds, disposed crosswise above one another, and presents four free vertical faces, whence it has been called a *chest* by the miners.

It is usually on Saturday that the fire is applied to all the piles of fagots distributed through the course of the week. Those in the upper floors of exploitation are first burned, in order that the inferior piles may not obstruct, by their vitiated air, the combustion of the former. Thus, at 4 o'clock in the morning, the fires are kindled in the upper ranges; from pile to pile, the fireman and his assistant descend towards the lower floors, which occupies them till 3 o'clock in the afternoon. Vainly should we endeavor to describe the majestic and terrific spectacle which the fire presents, as it unfolds its wings under its metallic vaults, soon filled with vast volumes of smoke and flame. Let us mark the useful effect which it produces.

When the flame has beat for a few instants on the beds of ore, a strong odor of sulphur, and sometimes of arsenic is perceived; and soon thereafter loud detonations are heard in the vaults. Suddenly the flame is seen to assume a blue color, or even a white; and at this period, after a slight explosion, flakes of the ore, of greater or less magnitude, usually fall down on the fire, but the chief portion of the heated mineral still remains fixed to the vault. The ores pass now into a shattered and divided condition, which allows them afterwards to be detached by long forks of iron. In this manner the fire, volatilizing entirely some principles, such as sulphur, zinc, arsenic, and water, changing the aggregation of the constituent parts of the ore, and causing fissures by their unequal expansibilities, facilitates the excavation of such materials as resist by their tenacity the action of gunpowder.

The combustion goes on without any person entering the mine from Saturday evening till Monday morning, on which day, the fireman and his assistants proceed to extinguish the remains of the bonfires. On Monday also some piles are constructed in the parts where the effect of the former ones has been incomplete; and they are kindled after the workmen have quitted the mine. On Tuesday all hands are employed in detaching the ores, in sorting them, taking them out, and preparing new piles against the next Saturday.

The labor of a week consists for every man of five posts during the day, each of 8 hours, and of one post of four hours for Saturday. Moreover, an extra allowance is made to such workmen as employ themselves some posts during the night.

The labor of one compartment or *atelier* of the mine consists therefore in arranging the fagots, in detaching the ore which has already experienced the action of the fire, in breaking the blocks obtained, in separating the ore from the *debris* of the pile, and, whenever it may be practicable or useful, in boring holes for blasting with gunpowder. The heat is so great in this kind of mine, that the men are obliged to work in it without clothing.

We have already remarked, that besides the working by fire, which is chiefly used here, recourse is sometimes had to blasting by gunpowder. This is done in order either to recover the bottom part or ground of the vaults on which the fire can act but imperfectly, to clear away some projections which would interfere with the effect of the pile, or lastly to strip the surrounding rock from the mass of the ore, and thence to obtain schist proper for the construction of the rubbish-terraces.

The blasting process is employed when the foremen of the workshop or mine-chamber judge that a hole well placed may separate enough of ore to pay the time, the repair of tools, and the gunpowder expended. But this indemnification is rarely obtained. The following statement will give an idea of the tenacity which the mineral deposite often presents.

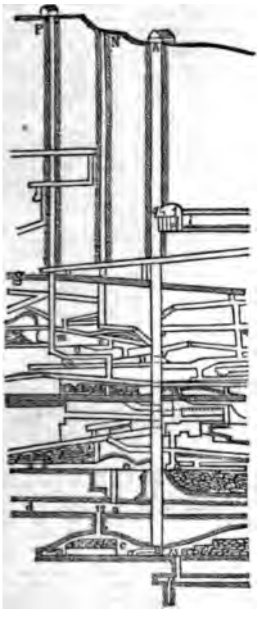
In 1808, in a portion of the Rammelsberg mine, the ore, consisting of extremely *compact iron and copper* pyrites, was attacked by a single man, who bored a mining hole, After 11 posts of obstinate labor, occupying altogether 88 hours, the workman, being vigilantly superintended, had been able to advance the hole to a depth of no more than 4 inches; in doing which he had rendered entirely unserviceable 126 punches or borers, besides 26 others which had been re-tipped with steel, and 201 which had been sharpened; 6¼ pounds of oil had been consumed in giving him light; and half a pound of gunpowder was required for blasting the bore. It was found from a calculation made upon these facts by the administration of mines, that every inch deep of this hole cost, at their low price of labor, nearly a florin, value two shillings and sixpence.

It is therefore evident that though the timber, of which the consumption is prodigiously great, were much less abundant and dearer than it still is at Rammelsberg, mining by fire would be preferable to every other mode of exploitation. It is even certain, that on any supposition, the employment of gunpowder would not be practicable for every part of the mine; and if fuel came to fail, it would be requisite to renounce the workings at Rammelsberg, although this mountain still contains a large quantity of metals.

If in all mines the free circulation of air be an object of the highest importance, we must perceive how indispensable it must be in every part of a mine where the mode of exploitation maintains the temperature of the air at 112° Fahr., when the workmen return into it after the combustion of the piles, and in which besides it is necessary that this combustion be effected with activity in their absence. But in consequence of the extent and mutual ramifications of the workings, the number of the shafts, galleries, and their differences of level, the ventilation of the mine is in a manner spontaneously maintained. The high temperature is peculiarly favorable to it. The aid of art consists merely in placing some doors judiciously, which may be opened or shut at pleasure, to carry on the circulation of the air.

In considering the Rammelsberg from its summit, which rises about 400 yards above the town of Goslar, we observe, first, beds of slaty sandstone, which become the more horizontal the nearer they approach to the surface. At about 160 yards below the top level there occurs, in the bosom of the slaty graywacke, a powerful stratum of shells impasted in a ferruginous sandstone. See D, *fig*. 730. In descending towards the face of the ore, the parallel stratification of the clay-slate which forms its walls and roof grows more and more manifest. Here the slate is black, compact, and thinly foliated. The inclination of the different beds of rock is indicated at B. The substance of the workable mass is copper and iron pyrites, along with sulphuret of lead, accompanied by quartz, carbonate of lime, compact sulphate of baryta, and occasionally gray copper (*fahlerz*), sulphuret of zinc, and arsenical pyrites.

737



The ores are argentiferous and auriferous, but very slightly so, especially as to the gold. It is the ores of lead and copper which contain the silver, and in the latter the gold is found, but without its being well ascertained in what mineral it is deposited. Sometimes the copper occurs in the native state, or as copper of cementation. Beautiful crystals of sulphate of lime are found in the old workings.

In *figs*. 736, 737, A B is the shaft of extraction, called the *Kahnenkuhler ;* N is the ventilation shaft, called *Breitlingerwetterschacht ;* P is the extraction shaft, called *Innierschacht*.

E F, is a new extraction-shaft, called *Neuer treibschacht*, by which also the water is pumped up; by A B, and E F, the whole extraction and draining are carried on. The ores are raised in these shafts to the level of the wagon-gallery (*galerie de roulage*) *i*, by the whims 1, *q*, provided with ropes and buckets. 1, 2, 3, 4, *fig*. 736, represent the positions of four water-wheels for working the whims; the first two being employed in extracting the ores, the last two in draining. The driving stream is led to the wheel 1, along the drift *l ;* whence it falls in succession upon the wheels 2, 3, 4. The general system of working consists of the following operation :—

1. The bed of ore is got at by the transverse galleries, *m*, *n*, *o*, *q*, R, *s*, which branch off from the extraction shaft, and terminate at the wall of the main bed;

2. Great vaults are scooped out at the level of the workings, by means of fire;

2. Great vaults are scooped out at the level of the workings, by means of fire;
3. The roofs of these vaults are progressively propped with mounds of rubbish;
4. The ores thus detached, or by blasting with gunpowder, are then collected;
5. Lastly, they are wheeled out to the day; and washed near z.:

COMPARATIVE TABLE of celebrated MINES in EUROPE and AMERICA. By F. BURR, Esq

(*Quarterly Mining Review for July*, 1835, p. 60.)

	CONSOLIDATED AND UNITED MINES. (At present the richest mines in Cornwall.)	VETA GRANDE MINES. (At present the richest mines in Mexico.)	MINE OF VALENCIANA. (Richest of the Mexican mines at the beginning of the present century.)	MINE OF HIMMELSFÜRST. (Richest of the Saxon mines at the beginning of the present century.)
Situation - -	Two miles east of Redruth.	Four miles north of Zacatecas.	One mile north of Guanaxuato.	Two miles south-east of Freyburg.
Elevation - -	Elevation of the surface above the level of the sea, from 200 to 300 ft.; depth of the bottom of the mine below the level of the sea, about 1,370 feet.	Elevation of the surface above the level of the sea, supposed to be about 6000 feet. Elevation of the bottom of the mine above the level of the sea, probably near 5,000 feet.	Elevation of the surface above the level of the sea, 7,617 feet. Elevation of the bottom of the mine above the level of the sea, 5,730 feet.	Elevation of the surface above the level of the sea, 1,346 feet. Elevation of the bottom of the mine above the level of the sea, 263 feet.
Nature of the rock	Primary clay slate resting immediately on granite, a short distance westward of the mines. The clay slate is intersected by numerous channels of porphyry, which have nearly the same direction as the mineral veins, and are often of considerable width. The porphyry sometimes appears also to form large irregular masses in the clay slate. Both rocks are traversed by veins of quartz and clay intersecting the metalliferous veins.	Transition clay slate, alternating with dolomite, and occasionally with greywacke. This clay slate is sometimes decomposed; it rests on syenitic rocks, and is in some places covered with porphyry.	The *Veta Madre* of Guanaxuato, upon which this mine is worked, traverses both clay slate and porphyry, but it is most productive in the former rock. The clay slate is considered by Humboldt to belong to the transition class, but situate near the limits of primary formations. This rock in depth passes into chlorite slate, and talc slate. It contains subordinate beds of syenite, hornblende slate, and serpentine. The porphyry rests upon the clay slate, and is conformable to it, both in direction and stratification.	The rock prevailing in the neighbourhood of Freyberg, in which this and most of the other mines are situate, is a formation of primary gneiss.
Nature of the metalliferous deposits	In the consolidated mines, the eight following lodes are extensively worked:—Wheal Fortune lode, Cusvea lode, Deeble's lode, Old lode, Taylor's lode, Tregonning's lode, Martin's lode, and Glover's lode. In the united mines, the principal workings are upon the Old lode, and about five or six others are more or less productive. Numerous smaller lodes or "branches" occur also in both mines. The principal lodes are from 2 or 3, to 7 or 8 feet wide; the "branches" are generally 12 or 18 inches wide. The direction of the lodes varies from nearly east and west to about 20 degrees north of east and south of west. The underlie of the principal lodes is from 2 to 3 feet per fathom north, that of the smaller ones about the same south.	One principal vein (the *Veta Grande*) which is generally separated into three branches, and sometimes into four. When ramified, the width extends to 60 or 70 feet; when united, it varies from 8 or 10 to 20 or 30 feet. The branches are generally about 10 or 12 feet wide; and the upper one is most productive. The direction of the Veta Grande is from 30 to 40 degrees south of east, and north of west, and its underlie, from two to three feet per fathom south. Other veins of less size occur in the neighbourhood of the Veta Grande, which cross it at an acute angle. One of these appears to heave the vein for about 700 feet, being the most remarkable derangement of the kind on record.	One Veta (the *Veta Madre*) which is often separated into three branches, extending from 120 to 160 feet in width. When not ramified, its width varies from 20 or 30 to 60 or 70 feet, but is more commonly from 40 to 50 feet. The direction of the vein is north-west and south-east; its underlie is south, and about five or six feet per fathom.	There are five veins worked in this mine. The principal vein (*Teich-flache*) is from one foot six inches to three feet in width, the others are from six to twelve inches wide. The direction of this vein is nearly north and south, its underlie is west, and about three feet per fathom. Some of the other veins intersect it.
Ores - -	Chiefly copper ore, occasionally native copper, blue and green carbonate of copper. Tin, or oxide of tin, also occurs, but not in very great abundance.	Chiefly red silver, native silver, sulphuret of silver, and argentiferous pyrites.	Sulphuret of silver, native silver, prismatic black silver, red silver, native gold, argentiferous galena.	Argentiferous sulphuret of lead, native silver, sulphuret of silver, red silver.
Produce of the ores	9¼ per cent of fine copper; average produce in 100 parts of ore.	3½ oz. per quintal.	Four ounces of silver per quintal of 100 lbs., equivalent to 2½ parts of metal in 1,000 of ore, or ¼ per cent.	Six to seven ounces of silver per quintal of 100 lbs. Equivalent to from 3¾ to 4⅜ parts of metal in 1,000 of ore, or from 3-8ths to nearly ½ per cent.
Veinstone -	Chiefly quartz, of which many varieties occur.	Chiefly quartz, occasionally amethyst, carbonate of lime, and sulphate of barytes.	Quartz, amethyst, carbonate of lime, pearlspar, and hornstone.	Quartz, pearlspar, and calcareous spar.
Mineral substances accompanying the ores - -	The ores are generally accompanied by "gossan"* in the backs of the lodes, by blende, and by iron, and arsenical pyrites in depth.	The ores are generally accompanied by blende, sulphuret of antimony, and iron pyrites.	The ores are accompanied by blende, spathose iron, copper and iron pyrites.	The ores are accompanied by blende, spathose iron, and a little iron and arsenical pyrites.
Depth of the principal shafts -	*Woolf's engine-shaft*, 248 fathoms; Pearce's *engine-shaft*, 275 fathoms. Some of the other engine shafts are scarcely inferior in depth.	*Tiro General*, 182 fathoms; *Gallega* shaft, 128 fathoms.	*Tiro General*, 310 fathoms.	*Frankenschacht*, 180 fathoms.

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* Gossan, or Gozzan; oxide of iron and quartz.

COMPARATIVE TABLE of celebrated MINES in EUROPE and AMERICA.

By F. Burr, Esq.—*Continued.*

	CONSOLIDATED AND UNITED MINES. (At present the richest mines in Cornwall.)	VETA GRANDE MINES. (At present the richest mines in Mexico.)	MINE OF VALENCIANA. (Richest of the Mexican mines at the beginning of the present century.)	MINE OF HIMMELSFÜRST. (Richest of the Saxon mines at the beginning of the present century.)
lit at the shafts	At Woolf's engine-shaft, 12 fathoms. The average depth of the adit at the other engine-shafts is about 30 or 40 fathoms.	There is no adit to this mine.	There is no adit to this mine.	The adit at the shaft called *Franken-schacht*, is 47 fathoms in depth.
' water	Varies from 2,000 to 3,000 gallons per minute.	About 80 gallons per minute.	The Valenciana was a dry mine from its commencement in 1760 to 1780, when it first became troubled with water, in consequence of some of the workings being inadvertently communicated with the adjoining mine of Tepeyac; which, although upon the same vein, was extremely wet. The quantity of water raised during the late working appears to have been about 110 gallons per minute, but the regular influx was much less.	80 gallons per minute.
hich the aised	About 220 fathoms at the consolidated mines, at the united mines, about 110 fathoms.	On an average about 180 fathoms.	310 fathoms.	133 fathoms.
loyed in	9 steam-engines; 2 of 90-inch cylinder, 3 of 85, 1 of 80, and 2 of 65. A water wheel, 48 feet in diameter.	Usually 10 malacates.*	A steam-engine of 30 inch-cylinder, and 7 malacates.	Two water-wheels, each 42 feet in diameter.
uivalent horse-	1,500 constantly at work, or a total number of above 4,500.	32 horses constantly working, or a total number of about 100 horses.	65 horses constantly at work, or a total number of about 200.	16 horses constantly at work, or a total number of about 50.
nual ex- rainage	12,700*l.* taking the average of the last ten years.	20,000*l.* per annum.	About 40,000*l.* per annum.	Cannot be ascertained, but evidently very small.
' ore an- duced	16,400 tons of copper ore, a few tons of tin ore.	21,380 tons of silver ore.	32,500 tons of silver ore.	630 tons of silver ore.
metal	1,517 tons of fine copper, a little tin.	153,000 lbs. troy of silver.	222,900 lbs. troy silver.	6,160 lbs. troy of silver.
rns, or	119,800*l.*	423,400*l.* per annum.	About 600,000*l.*	About 18,000*l.*
e above of the	93,500*l.* exclusive of lord's dues; 98,500*l.* including lord's dues.	252,170*l.* per annum.	197,900*l.* per annum.	9,600*l.* per annum.
; to the s	21,000*l.* per annum.	171,240*l.* per annum	118,750*l.* per annum.	2,660*l.* per annum.
capital	75,000*l.*	130,000*l.*	Cannot be ascertained, but known to have been very small.	Cannot be ascertained, but probably very small.
capital	280 per cent. after paying back the original capital.	Nearly 700 per cent. after paying back the original capital.	Not known, but certainly many hundred per cent.	Not known, but probably very high.
of costs	Costs exclusive of lord's dues, 78 per cent.	About 59½ per cent.	Costs 60 per cent. In the nine years following, the proportion was 80 per cent., at the end of that time the working of the mine was stopped by the revolution, in the year 1809.	Costs 73 per cent.
men em-	About 2,500 persons, of whom about 1,450 are employed under ground.	About 900, of whom nearly 600 are employed under ground.	3,100 Indians and Mestizoes, of whom 1800 are employed under ground.	700 miners, of whom 560 are employed under ground.
e miners	Probably about 3 shillings on an average.	About 8 or 9 shillings per day.	From 4 to 5 shillings.	About 1*s.* 6*d.* per day.
nd ex- owder	- - -	- - -	1,480 cwt.; value 15,830*l.*	240 cwt.; value 1,070*l.*
which are dis-	Sold to the smelting companies, and smelted by them at Swansea, in South Wales.	Chiefly reduced by the company at the hacienda of Sanceda, by smelting and amalgamation.	Sold to the *Rescatadores*, and reduced by smelting and amalgamation at haciendas, in the neighbourhood of Guanaxuato.	Delivered to the Government, reduction works in the neighbourhood of Freyberg, where they are partly smelted, and partly amalgamated.

Average of the last Ten Years.

Average of the last Six Years.

Average year at the end of the Eighteenth Century.

Average at the end of the Eighteenth Century.

VENTILATION OF MINES.

men penetrate by narrow passages into the interior of the earth, their respir-
ned to the combustion of candle and gunpowder, are not long of vitiating
The decomposition of wood contributes to the same effect, as also the
ped itself, especially in coal mines, by the carburetted hydrogen and carbonic
lved, and from the absorption of oxygen by pyrites. In many cases, arsenical
curial *vapours are disengaged.* Hence the necessity of maintaining in sub-

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* Malacate; a horse whim.

terranean cavities a continual circulation of air, which may renew the atmosphere round the miners. The whole of the means employed to produce this effect, constitutes what is called the *ventilation of mines.*

These means are divided into *natural* and *artificial.* The *natural means* are the currents produced by the difference of density between the air of mines and the external air; the *artificial* are air-exhausters or condensers, fires, &c.

The temperature of the air of the subterranean workings surpasses the mean temperature of the place in which the mine is opened. Hence it is lighter in winter, but in summer often heavier than the air of the atmosphere. For this reason, when the mine presents two openings at different levels, the air naturally flows out by the most elevated in winter, and by the lowest in summer. We may take advantage of this circumstance, to lead the air into the bottom of even a very long gallery, opening into the side of the mountain, by piercing a shaft into its roof at some distance from the entrance, and dividing the gallery by a horizontal floor into two parts, which have no mutual communication, except at the furthest extremity—the upper part communicating with the shaft, and the under with the mouth of the gallery. If the two compartments have different dimensions, the air in the smaller sooner comes into an equilibrium of temperature with the rock; and the difference of temperature of the two compartments is sufficient to produce a current. If a streamlet of water flows through this gallery, it facilitates the flow of the air along the lower compartment. If a mine has several openings situated on the same level, it rarely happens but some peculiar circumstance destroys, during the colds of winter and the heats of summer, the equilibrium of the air. But in spring and autumn, when the external air is nearly of the same temperature with that of the mines, the above-named causes are almost always too feeble to excite an issuing current. This effect is, however, frequently obtained by raising over one of the shafts a chimney 20 or 30 yards high, which alone produces the effect of an opening at a different level. It has been remarked that stormy weather usually deranges every system of ventilation. See Pitcoal and Ventilation.

MINIUM. (Eng. and Fr.; *Red lead; Mennige,* Germ.) This pigment is a peculiar oxyde of lead, consisting of two atoms of the protoxyde and one of the peroxyde; but, as found in commerce, it always contains a little extra protoxyde, or yellow massicot. It is prepared by calcining lead upon a reverberatory hearth with a slow fire, and frequent renewal of the surface with a rake, till it becomes an oxyde, taking care not to fuse it. The calcined mass is triturated into a fine powder in a paint mill, where it is elutriated with a stream of water, to carry off the finely levigated particles, and to deposite them afterwards in tanks. The powder thus obtained, being dried, is called massicot. It is converted into minium, by being put in quantities of about 50 pounds into iron trays, 1 foot square, and 4 or 5 inches deep. These are piled up upon the reverberatory hearth, and exposed during the night, for economy of fuel, to the residuary heat of the furnace, whereby the massicot absorbs more oxygen, and becomes partially red lead. This, after being stirred about, and subjected to a similar low calcining heat once and again, will be found to form a marketable red lead.

The best minium, however, called *orange mine,* is made by the slow calcination of good white lead (carbonate) in iron trays. If the lead contains either iron or copper, it affords a minium which cannot be employed with advantage in the manufacture of flint-glass, for pottery glazes, or for house-painting.

Dumas found several samples of red lead which he examined to consist of the chemical sesquioxyde and the protoxyde, in proportions varying from 50 of the former and 50 of the latter, to 95·3 of the former and 4·7 of the latter. The more oxygen gas it gives out when heated, the better it is, generally speaking. See Naples Yellow.

MINT. (*Monnaie,* Fr.; *Munze,* Germ.) The chief use of gold and silver is to serve for the medium of exchange in the sale and purchase of commodities, a function for which they are pre-eminently fitted by their scarcity, by being unalterable by common agents, and condensing a great value in a small volume. It would be very inconvenient in general to barter objects of consumption against each other, because their carriage would be expensive, and their qualities, in many cases, easily injured by external agents, &c. Gold is exempt from spontaneous change, and little costly in conveyance. Mankind at a very early period recognised how much easier it was to exchange a certain weight of gold or silver for objects of commerce, than to barter these objects themselves; and thenceforth all agreed to pay for their purchases in bars or ingots of these precious metals. But as their intrinsic value depends upon their purity, it became necessary to stamp on these bars their standard quality and their weight.

The inconvenience of using ingots in general trade, on account of the difficulty of defining fractional values, has determined governments to coin pieces of money, that is, quantities of metal whose weight and standard were made known and guarantied by the effigies of the prince. It is true, indeed, that kings have become frequently coiners of base money, by altering the weight and purity of the pieces apparently guarantied by their impress. By such reductions, modern coins represent less of the precious metal than they did long ago. The *ordonnance* of 755, for the coining of *sous* in France, proves that there was then as much fine silver in a single *sous* as there is now in a piece of 5 francs. During the last two centuries, indeed, silver coins have been diminished two thirds in weight.

But since knowledge has become more generally diffused, it has been shown that these frauds are equally injurious to the prince and to public faith. A sovereign may, it is true, declare by a decree that a shilling-piece is to be held worth five; but let us consider the consequences of this decree. All the individuals who have rents or capital sums to receive will be ruined, by getting in metallic value only one fifth of what is due to them; for although the *nominal* value should be the same as what they are entitled to, the intrinsic value would be but a fifth of the former; so that when they go to purchase the necessaries or comforts of life, the dealer who sells them will at once raise their price five-fold. Each article of merchandise would thus acquire a nominal price 5 times greater; and he who had received payment of a debt in that money could not with it procure more than one fifth of the goods he could have previously commanded. That fraudulent law would, therefore, favor the debtors at the expense of the creditors; and as the state is commonly a great debtor, especially when it has recourse to the depreciation of the currency, it is obvious, that however illicit the gain which it makes, it still does gain; and this is the reason why princes have so often tampered with the mint. But let us examine the other consequences of this decree.

If the sovereign is a debtor, he is also a creditor and consumer, and even the most considerable of any. The taxes which he imposes are paid him in this deteriorated money, returned to him at its nominal value; and the purveyors of his armies, his buildings, and his household, sell him their commodities only at the actual market price. We may infer from this simple development that the coin with which he pays for any object has the same intrinsic value as the object; and that the name given to the coin is of no consequence. The prince may call it a crown, a ducat, or a rix-dollar at his pleasure; and he may assign any value to it that his caprice may suggest, yet this will not affect its value; for this is fixed beyond his control by the general nature of things. The prince may, indeed, at the outset, have profited by defrauding his creditors, and by authorizing each debtor to imitate him, but he will soon lose whatever he may have gained; and he will thus learn to his cost that it was bad policy to sacrifice his character by giving an example of a fraud so truly unprofitable in the issue. Moreover, he will lose still as much in the following years, because his treasury will receive only one fifth part of the taxes, unless he has quintupled the imposts. It may be said, indeed, that he might do the one thing along with the other. But every one knows that this power is neither generally permitted to princes, nor, if it were, could it be safely exercised. Serious political crises would combine to endanger the stability of the government; which besides, as the main consumer in the nation, must lose always as much as it seems to gain.

It is therefore manifest, that the alteration of the standard and weight of the coinage is at once a crime and a ruinous action for the sovereign power to commit; and hence such disastrous measures have been long abandoned in all well-regulated states. A gold sovereign is intrinsically worth 20 shillings, minus the cost of coinage; for were it worth more, all our sovereign pieces would be exported or melted down, to obtain the difference of value, however trifling it might be; and were it worth less, it would be the source of loss similar to what the state occasions when it depreciates the coin.

To comprehend the true value of a coin, we must regard this piece as an article of merchandise, whose value depends, as that of every thing else, on its usefulness, the esteem in which it is held, and the demand for it in the market. Grain increases in value when there are few sellers and many buyers; gold and silver are in the same predicament. The value of these metals is much augmented, indeed, by the universal currency they obtain when struck into money; a value additional to what they possess as objects of the arts. This value of the precious metals changes with time and place, like that of every merchandise; their abundance, since the discovery of America, has greatly lowered their value; that is, with the same weight of metal, we cannot at the present day purchase the same quantity of corn, land, wool, &c. as formerly. In the countries where silver abounds, this metal has less value, or, in other terms, commodities are dearer. Hence the metal tends to resume its equilibrium in flowing into those places where it is rarer; which means, that the consumer prefers purchasing his commodities there, rather than in another place, if he can easily transport them to where they are dearer.

It was formerly believed that a country is rich when it has a great deal of gold and silver; but this popular illusion has passed away. Spain has never been poorer than since the discovery of America, because its national industry has been ruined, and the capitals merely passed through its hands to spread over the rest of Europe, from which it was obliged to import every thing that its want of home manufactures made it necessary to procure from abroad. We may add to these the prodigalities of the court, which, supposing its wealth inexhaustible, tried to corrupt all the ministers of the other powers, in furtherance of the chimera of universal dominion. The richest state is that in which there is most industry, whereby the inhabitants may procure every thing indispensable to the conveniences and comforts of life. Gold as a useful metal, and a medium of exchange, is undoubtedly very precious, and an adequate quantity for these exchanges must be had; but as it is good for very little besides, nay, as an excess is even hurtful, it soon begins to fly of itself towards the places where it is more needed or less common.

With regard to the relative value of gold and silver, several details have already been given in our view of the mineral wealth of the globe. Three centuries ago, an ounce of gold was worth at London or Paris 10 ounces of silver; now it may be exchanged for 15 ounces and a half.

The *par* of two coins results from the comparison of their weight and standard fineness. Let us take for an example the conversion of English gold sovereigns worth 20 shillings or a pound sterling, in relation to the French louis of 20 francs. The standard of the sovereign gold is 0·917, fine gold being 1000; its weight is 125,256 gr. English, or 7·980855 grammes; by multiplying this weight into its standard, we have a product of 7·318444035; this is, in grammes, the quantity of pure gold contained in the sovereign piece. The piece of 20 francs has a legal standard of 0·9; and multiplying this number by the weight of the louis, 6·45161 grammes, we find that it contains 5·806449 of pure metal. We then make this proportion:—

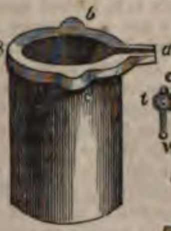
As 5·806449 : 20 francs : : 7·31844 : 25·2079 francs; or the value of the English sovereign is nearly 25·21 francs, in French gold coin. A similar calculation may be made for silver coins. The French rule for finding the *par* of a foreign gold coin, or its intrinsic value in francs, is to multiply its weight by its standard or titre, and that product by $3\frac{4}{9}$. The par of foreign silver money, or its intrinsic value in francs, is obtained by multiplying its weight in grammes by its standard in thousand parts, and by $\frac{2}{9}$. The French 5-franc piece has its standard or titre at 0·9, and weighs 25 grammes.

The assaying of gold for coin and trinkets requires very delicate management. The French take half a gramme at most (about $7\frac{1}{2}$ grains) of gold, and fuse it with thrice its weight of silver, as already described under ASSAY. The parting is the next operation. For this purpose the button of gold and silver alloy is first hammered flat on a piece of steel, and then made feebly red hot in burning charcoal or over a lamp flame. After being thus annealed, the metal is passed through the rolling press, till it be converted into a plate about $\frac{1}{70}$ of an inch thick. After annealing this riband, it is coiled into a spiral form, introduced immediately into a small matrass of a pear shape, an assay matrass, and about 500 grains of nitric acid, sp. grav. 1·185, are poured over it. Heat being now applied to the vessel, the solution of the silver and copper alloys ensues, and after 22 minutes of constant ebullition, the liquid is poured off and replaced by an equal quantity of nitric acid, likewise very pure, but of the density 1·28. This is made to boil for about 10 minutes, and is then poured off, when the matrass is filled up with distilled water to the brim. In conclusion, a small annealing crucible is inverted as a cup over the mouth of the matrass, which is now turned upside down with a steady hand; the slip of metal falls into the crucible through the water; which by sustaining a part of its weight softens its descent and prevents its tearing. The matrass is then dexterously removed, without letting its water overflow the crucible. The water is gently decanted from the crucible, which is next covered, placed in the middle of burning charcoal, and withdrawn whenever it becomes red hot. After cooling, the metal slip is weighed very exactly, whence the weight of fine gold in the alloy is known. Stronger acid than that prescribed above would be apt to tear the metallic riband to pieces, and it would be difficult to gather the fine particles of gold together again. The metallic plate becomes at last merely a golden sieve, with very little cohesion. When copper is to be separated from gold by cupellation, a higher temperature is requisite than in cupelling silver coin.

The coining apparatus of the Royal Mint of London is justly esteemed a masterpiece of mechanical skill and workmanship. It was erected in 1811, under the direction of the inventor, Mr. Boulton; and has since been kept in almost constant employment.

The melting pots (*fig.* 738) are made of cast-iron, and hold conveniently 400 pounds of metal. They are furnished with a spout or lip for pouring out the metal, and with two ears, on which the tongs of the crane lay hold in lifting them out of the furnace. The pot rests on pedestals on the grate of the furnace, and has a ring cast on its edge to prevent the fuel falling into it. Whenever it becomes red hot, the metal properly prepared and mixed, so as to produce an alloy containing 0·915 parts of gold, is put in, and during the melting, which occupies some hours, it is occasionally stirred. The moulds are meanwhile prepared by warming them in a stove, and thereafter by rubbing their inside surfaces with a cloth dipped in oil, by which means the ingots cast in them get a better surface. *Fig.* 739 represents a side view of the carriage, charged with its moulds. When the proper number of moulds is introduced, the screws at the end, represented at *t t*, are screwed fast, to fix them all tight.

738



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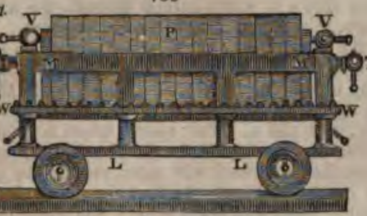
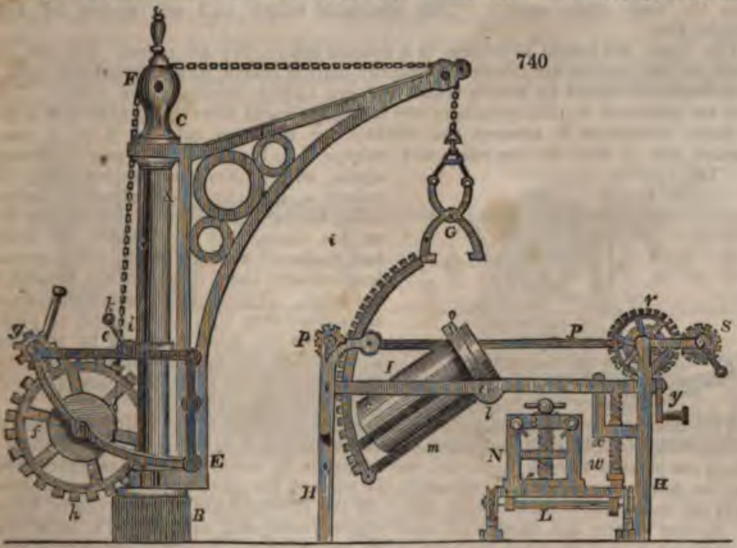


The pot of fused metal is lifted out of the furnace *b;* the crane (*fig.* 740) then swung round, and lowered down into the cradle *l*, *m*, *n*, *o* of the pouring machine, until the ring on the edge of it rests on the iron hoop *n*, which, being screwed tight up, holds it secure, and the crane-tongs are removed. One of the assistants now takes the winch handle *s* in one hand, and *y* in the other. By turning *y* he moves the carriage forward, so as to bring the first mould beneath the lip of the melting pot; and by turning *s*, he inclines the pot, and pours the metal into the mould. He then fills the other moulds in succession. The first portion of liquid metal is received in a small iron spoon, and is reserved for the assay-master; a second sample is taken from the centre of the pot, and a third from the bottom part. Each of these is examined as to its quality.

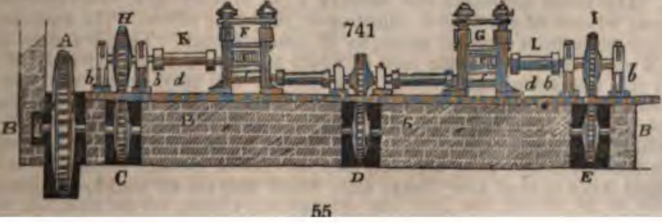
740



The ingots, which are about 10 inches long, 7 broad, and 6 tenths of an inch thick, are now carried to the rolling mill,

Fig. 741, where A represents a large spur wheel, fixed on the extremity of a long

741

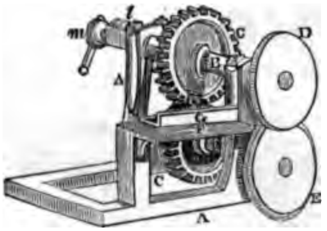


horizontal shaft B B, extending beneath the whole mill. This wheel and shaft are driven by a smaller wheel, fixed on the main or fly-wheel shaft of a steam engine of 36-horse power. The main shaft B of the rolling mill has wheels C, D, E fixed upon it, to give motion to the respective rollers, which are mounted at F and G, in strong iron frames, bolted to the iron sills *a a*, which extend through the whole length of the mill, and rest upon the masonry, in which the wheels are concealed. The two large wheels C and E give motion to the wheels H, I, which are supported on bearings between two standards *b*, *b*, bolted down to the ground sills. On the ends of the axes of these wheels are heads for the reception of coupling boxes *d*, *d*, which unite them to short connecting shafts K L; and these again, by means of coupling boxes, convey motion to the upper rollers *e*, *e*, of each pair, at F and G. The middle wheel D upon the main shaft B gives motion to the lower rollers in a similar manner. Thus both the rollers *e*, *f* of each frame receive their motion from the main shaft with equal velocity, by means of wheels of large radius, which act with much more certainty than the small pinions usually employed in rolling mills to connect the upper and lower rollers, and cause them to move together.

The rolling mill contains four pairs of rollers, each driven by its train of wheel work; the mill, therefore, consists of two such sets of wheels and rollers as are represented in our figure. The two shafts are situated parallel to each other, and receive their motion from the same steam engine. This admirable rolling mill was erected by John Rennie, Esq.

The ingots are heated to redness in a furnace before they are rolled. The two furnaces for this purpose are situated before two pairs of rollers, which, from being used to consolidate the metal by rolling whilst hot, are termed breaking-down rollers. Two men are employed in this operation; one taking the metal from the furnace with a pair of tongs, introduces it between the rollers; and the other, catching it as it comes through, lifts it over the top roller, and returns it to his fellow, who puts it through again, having previously approximated the rollers a little by their adjusting screws. After having been rolled in this manner four or five times, they are reduced to nearly two tenths of an inch thick, and increased lengthwise to about four times the breadth of the ingot. These plates, while still warm, are rubbed over with a dilute acid or *pickle*, to remove the color produced by the heat, and are then cut up into narrow slips across the breadth of the plate, by means of the circular shears *fig*. 742.

742

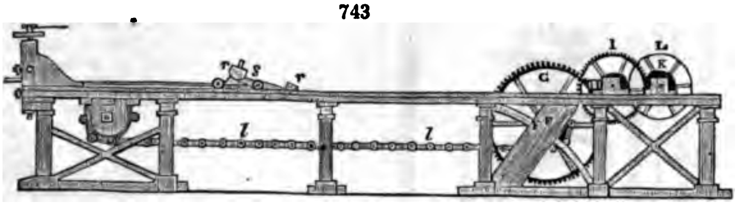


This machine is worked by a spur-wheel at the extremity of the main shaft B of the rolling mill (*fig*. 741.) It consists of a framing of iron A A, supporting two shafts B B, which are parallel to each other, and move together by means of two equal spur-wheels C C, the lower one of which works with the teeth of the great wheel above mentioned, upon the main shaft of the rolling mill. At the extremities of the two shafts, wheels or circular cutters are fixed with their edges overlapping each other a little way. F represents a shelf on which the plate is laid, and advanced forward to present it to the cutter; and G is a ledge or guide, screwed down on it, to conduct the metal and to regulate the breadth of the piece to be cut off. Hence the screws which fasten down the ledge are fitted in oblong holes, which admit of adjustment. The workman holds the plate flat upon the surface F, and pushing it towards the shears, they will lay hold of it, and draw it through until they have cut the whole length. The divided parts are also prevented from curling up into scrolls, as they do when cut by a common pair of shears; because small shoulders on E and D, behind the cutting edge, keep them straight. Behind the standard, supporting the back pivots of the shafts B B of the cutter, is a frame *l*, with a screw *m* tapped through it. This is used to draw the axis of the upper cutter D endwise, and keep its edge in close contact with the edge of the other cutter E. The slips or ribands of plate are now carried to the other two pairs of rollers in the rolling mill, which are made of case-hardened iron, and better polished than the breaking-down rollers. The plates are passed cold between these, to bring them to exactly the same thickness; whence they are called adjusting or planishing rollers. The workman here tries every piece by a common gauge, as it comes through. This is a piece of steel having a notch in it; the inside lines of which are very straight, and inclined to one another at a very acute angle. They are divided by fine lines, so that the edge of the plate being pressed into the notch, will have its thickness truly determined by the depth to which it enters, the divisions showing the thickness in fractions of an inch.

In rolling the plate the second time, all the plates are successively passed through the rollers; then the rollers being adjusted, they are passed through another time. This is repeated thrice or even four times; after which they are all tried by the gauge, and thus sorted into as many parcels as there are different thicknesses. It is a curious circumstance, that though the rollers are no less than 14 inches in diameter, and their frame proportionally strong, they will yield in some degree, so as to reduce a thick plate in a less degree than a thin one; thus the plates which have all passed through the same rollers, may be of 3 or 4 different degrees of thickness, which being sorted by the gauge into as many parcels, are next reduced to the exact dimension, by adapting the rollers to each parcel. The first of the parcel which now comes through is tried, by cutting out a circular piece with a small hand machine, and weighing it. If it proves either too light or too heavy, the rollers are adjusted accordingly, till by a few such trials they are found to be correct, when all the parcel is rolled through. The trial plates which turn out to be too thin, are returned as waste to the melting-house. By these numerous precautions, the blanks or circular discs, when cut out by the next machine, will be very nearly of the same weight; which they would scarcely be, even if the gauge determined all the plates to the same thickness, because some being more condensed than others, they would weigh differently under the same volume.

A great improvement has been made on that mode of lamination, by the late Mr. Barton's machine for equalizing the thickness of slips of metal for making coin, which has been for several years introduced into the British mint. A side elevation is shown in *fig.* 743, and a plan in *fig.* 744. It operates in the same way as wire-drawing mechanisms; namely, pulls the slips of metal forcibly through an oblong opening, left between two surfaces of hardened steel. The box or case which contains the steel dies, composed of two hardened cylinders, is represented at C in *fig.* 743. The pincers employed to hold the metal, and draw it through, are shown at *s r*.

743



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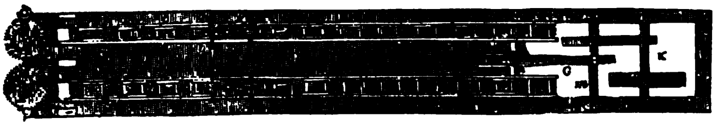


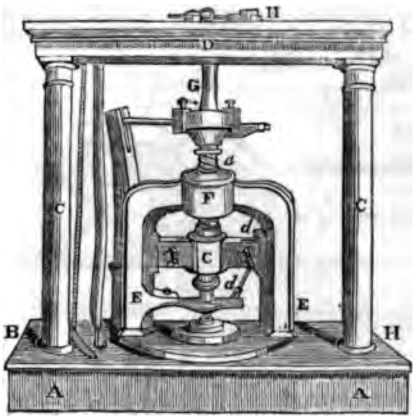
The slips of metal to be operated on by the drawing machine, are first rendered thinner at one end, that they may be introduced between the dies, and also between the jaws of the pincers. This thinning of the ends is effected by another machine, consisting of a small pair of rollers, mounted in an iron frame, similar to a rolling-mill. The upper roller is cylindrical, but the lower is formed with 3 flat sides, leaving merely portions of the cylinder entire, between these flat sides. The distance between the centres of the rollers is regulated by screws, furnished with wheels on their upper ends, similar to what is seen in the drawing dies at C. The two rollers have pinions on their axes, which make them revolve together; they are set in motion by an endless strap passing round a drum, upon whose axis is a pinion working into the teeth of a wheel fixed upon the axis of the lower roller.

The end of a slip of metal is presented between the rollers while they are in motion, not on that side of the roller which would operate to draw in the slip between them, as in the rolling-press above described, but on the contrary side, so that when one of the flat sides of the under roller fronts horizontally the circumference of the upper roller, an opening is formed, through which the slip of metal is to be inserted until it bears against a fixed stop at the back of the rollers. As the rollers continue to turn round, the cylindrical portions come opposite to each other, and press the metal between them, forcing it outwards, and rendering the part which has been introduced between the rollers as thin as the space between their cylindrical surfaces. Thus the end of the slip of metal becomes attenuated enough to pass between the dies of the drawing machine, and to be seized by the pincers.

In using the drawing machine, a boy takes hold of the handle *s* of the pincers, their hook of connexion with the endless chain *l*, *l*, not shown in the present figure, being disengaged, and he moves them upon their wheels towards the die-box C. In this movement the jaws of the pincers get opened, and they are pushed up so close to the die-box that their jaws enter a hollow, which brings them near the dies, enabling them to seize the end of the slip of metal introduced between them by the action of the preparatory rollers. The boy now holds the handle *s* on the top of the pincers fast, and with his other hand draws the handle *x* backwards. Thus the jaws are closed, and the metal firmly griped. He now presses down the handle *x* till a hook on the under side of the pincers seizes the endless chain as it moves along, when it carries the pincers, and their slip of metal, onwards with it. Whenever the whole length of the metallic riband has passed through between the dies, the strain on the pincers is suddenly relieved, which causes the weight *r* to raise their hook out of the chain, and stop their motion. The machine in the mint has two sets of dies, and two endless chains, as represented in the plan, *fig.* 744. N N, are toothed wheels in the upper end of the die-box, furnished with pinions and levers, for turning them round, and adjusting the distance between the dies. A large spur-wheel G, is fixed upon the axis F, to give motion to the endless chains; see both figures. This spur-wheel is turned by a pinion H, fixed upon an axis *m*, extending across the top of the frame, and working in bearings at each end. A spur-wheel I, is fixed upon the axis *m*, and works into the teeth of a pinion K, upon a second axis across the frame, which carries likewise a drum wheel L, through which motion is communicated to the whole mechanism by an endless strap.

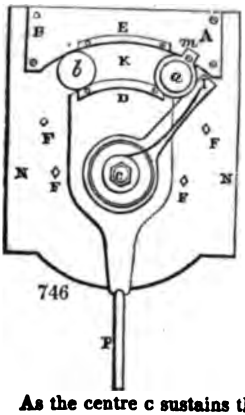
The cutting-out machine is exhibited in *fig.* 745. A A is a basement of stone to support an iron plate B B, on which stand the columns C C, that bear the upper part D of the frame. The iron frame of the machine E, F, E, is fixed down upon the iron plate B, B. The punch *d* is fixed in the lower part of the inner frame, and is moved up and down by the screw *a*, which is worked by wipers turned by a steam engine, impelling the lever H, and turning backwards and forwards the axis G, through a sufficient space for cutting the thickness of the metallic lamina. A boy manages this machine. There are twelve of them mounted on the same basement frame in a circular range contained in an elegant room, lighted from the roof. The whole are moved by a steam engine of 16 horse power.

745



The *blanks* or *planchets* thus cut out, were formerly adjusted by filing the edges, to bring them to the exact weight; a step which Mr. Barton's ingenious mechanism has rendered in a great measure unnecessary. The edge is then milled, by a process which Mr. Boulton desires to keep secret, and which is therefore not shown in our mint.

But the French mint employs a very elegant machine for the purpose of lettering or milling the edges, called the *cordon des monnaies*, invented by M. Gengembre, which has entirely superseded the older milling machine of M. Castaing, described in the Encyclopedias. The Napoleon coins of France bear on the edge, in sunk letters, the legend, *Dieu protège la France*; and those of the king, *Domine salvum fac regem*. This is marked before striking the blank or *flan*. One machine imprints this legend, and its service is so prompt and easy, that a single man marks in a day 20,000 pieces of 5 francs, or 100,000 francs.



746

Each of the two *arc* dies E, D, (*fig.* 746,) carries one half of the legend, engraved in relief on the curved face; these arcs are pieces of steel tempered very hard, and fixed with two screws, one immoveably at E, on the sill which bears the apparatus; the other at D, at the extremity of the lever P, D, which turns round the axis C. The letters of these demi-legends are exactly parallel, and inscribed in an inverse order on the dies. An alternating circular motion is communicated to the handle P. The curvatures of the two dies are arcs of circles described from the centre C; and the interval which separates them, or the difference of the radii, is precisely the diameter of the piece to be milled.

As the centre C sustains the whole strain of the milling, and produces, of consequence, a hard friction, this axis must possess a considerable size. It is composed of a squat truncated cone of tempered steel, which enters into an eye of the moveable piece P, D. This cone is kept on the plate of the metal N N, which bears the whole machine, by a nut, whose screw, by being tightened or slackened, gives as much freedom as is requisite for the movement of rotation, or removes the shake which hard service gives to the cone in its eye. The middle thickness of the hole of the moveable piece P, D, and the axis of the lever P, which terminates it, are exactly on a level with the engraved letters of the die, so that no strain can derange the moveable piece, or disturb the centre by its oscillations.

At *a* is a vertical tube, containing a pile of blanks for milling. It is kept constantly full; the tube being open at both ends, a little elevated above the circular space *a*, K, *b*, which separates the dies, and fixed by a tail *m* with a screw to the motionless piece A, B. The branch I, *c*, moveable with the piece P, D, passes under the tube, and pushes before it the blank at the bottom of the column, which is received into a small excavation in the form of a circular step, and carried forwards. Matters are thus so arranged as to regulate the issue of the blanks, one by one, on the small step, called the *posoir* (bed.)

As soon as the blank is pushed forwards into contact with the lower edge of the engraved grooves, it is seized by them, and carried on by the strain of milling, without exposing the upper or under surfaces of the *blank* to any action which may obstruct the printing on its edge.

The blank is observed to revolve between the two dies according as the lever P completes its course, and this blank passing from *a* to K, then to *b*, meets a circular aperture *b*, through which it falls into a drawer placed under the sill.

The range of the moveable lever P is regulated by four pieces, F, F, F, F, solidly sunk in the plate N, N, which bears the whole apparatus. A stud placed on this lever towards D, makes the arm of the *posoir* I *c* retire no farther than is necessary for the little blank to issue from the column; and a spring fixed to the centre *c*, and supported on a peg, brings back the *posoir*; so that when a screw I comes to strike against the column, the *posoir* stops, and the moveable die D, which continues its progress, finds the blank in a fit position for pressing, seizing, and carrying it on, by reaction of the fixed die E. Thus the edge of the blank is lettered in half a second. A hundred may easily be marked in about three minutes.

The coining press is the most beautiful part of the whole mechanism in the British mint; but the limits of this volume will not allow of its being figured upon an adequate scale. An engraving of it may be seen in the Encyclopedia Britannica.

The only attention which this noble machine requires is that of a little boy, who stands in a sunk place before the press, and always keeps the tube full of blanks. He has two strings, one of which, when pulled, will put the press in motion by the concealed mechanism in the apartment above; and the other string, when snatched, stops the press. This coining operation goes on at the rate of 60 or 70 strokes per minute; and with very few interruptions during the whole day. The press-room at the Royal Mint contains eight machines, all supported on the same stone base; and the iron beams between the columns serve equally for the presses on each side. The whole has therefore a magnificent appearance. The eight presses will strike more than 19,000 coins in an hour, with only a child to supply each. The grand improvement in these presses consists; 1. in the precision with which they operate to strike every coin with equal force, which could not be ensured by the old press impelled by manual labor; 2. The rising collar or steel ring in which they are struck, keeps them all of one size, and makes a fair edge, which was not the case with the old coins, as they were often rounded and defaced by the expansion of the metal under the blow; 3. The twisting motion of the upper die is thought to produce a better surface on the flat parts of the coin; but this is somewhat doubtful; 4. The feeding mechanism is very complete, and enables the machine to work much quicker than the old press did, where the workman, being in constant danger of having his fingers caught, was obliged to proceed cautiously, as well as to place the coin true on the die, which was seldom perfectly done. The feeding mechanism of the above press is a French invention; but Mr. Boulton is supposed to have improved upon it.

MIRRORS. See COPPER and GLASS.

MISPICKEL is arsenical pyrites.

MOHAIR is the hair of a goat which inhabits the mountains in the vicinity of Angora, in Asia Minor.

MOIRE'E METALLIQUE, called in this country crystallized tin-plate, is a variegated primrose appearance, produced upon the surface of tin-plate, by applying to it in a heated state some dilute nitro-muriatic acid for a few seconds, then washing it with water, drying, and coating it with lacker. The figures are more or less beautiful and diversified, according to the degree of heat, and relative dilution of the acid. This mode of ornamenting tin-plate is much less in vogue now than it was a few years ago,

MOLASSE is a sandstone belonging to the tertiary strata, employed under that name by the Swiss for building.

MOLASSES is the brown viscid uncrystallizable liquor, which drains from cane sugar in the colonies. See Sugar.

MOLYBDENUM (*Molybdène*, Fr.; *Molybdan*, Germ.) is a rare metal which occurs in nature sometimes as a sulphuret, sometimes as molybdic acid, and at others as molybdate of lead. Its reduction from the acid state by charcoal requires a very high heat, and affords not very satisfactory results. When reduced by passing hydrogen over the ignited acid, it appears as an ash-gray powder, susceptible of acquiring metallic lustre by being rubbed with a steel burnisher; when reduced and fused with charcoal, it possesses a silver white color, is very brilliant, hard, brittle, of specific gravity 8·6; it melts in a powerful air-furnace, oxydizes with heat and air, burns at an intense heat into molybdic acid, dissolves in neither dilute sulphuric, muriatic, nor fluoric acids, but in the concentrated sulphuric and nitric.

The protoxyde consists of 85·69 of metal, and 14·31 of oxygen; the deutoxyde consists of 75 of metal, and 25 of oxygen; and the peroxyde, or molybdic acid, of 66·6 of metal, and 33·4 of oxygen. These substances are too rare at present to be used in any manufacture.

MORDANT, in dyeing and calico-printing, denotes a body which, having a twofold attraction for organic fibres and coloring particles, serves as a bond of union between them, and thus gives fixity to dyes; or it signifies a substance which, by combining with coloring particles in the pores of textile filaments, renders them insoluble in hot soapy and weak alkaline solutions. In order properly to appreciate the utility and the true functions of mordants, we must bear in mind that coloring matters are peculiar compounds possessed of certain affinities, their distinctive characters being not to be either acid or alkaline, and yet to be capable of combining with many bodies, and especially with salifiable bases, and of receiving from each of them modifications in their color, solubility, and alterability. Organic coloring substances, when pure, have a very energetic attraction for certain bodies, feeble for others, and none at all for some. Among these immediate products of animal or vegetable life, some are soluble in pure water, and others become so only through peculiar agents. We may thus readily conceive, that whenever a dye-stuff possesses a certain affinity for the organic fibre, it will be able to become fixed on it, or to dye it without the intervention of mordants, if it be insoluble by itself in water, which, in fact, is the case with the coloring matters of safflower, annotto, and indigo. The first two are soluble in alkalis; hence, in order to use them, they need only be dissolved in a weak alkaline ley, be thus applied to the stuffs, and then have their tinctorial substance precipitated within their pores, by abstracting their solvent alkali with an acid. The coloring matter, at the instant of ceasing to be liquid, is in an extremely divided state, and is in contact with the organic fibres for which it has a certain affinity. It therefore unites with them, and, being naturally insoluble in water, that is, having no affinity for this vehicle, the subsequent washings have no effect upon the dye. The same thing may be said of indigo, although its solubility in the dye-bath does not depend upon a similar cause, but is due to a modification of its constituent elements, in consequence of which it becomes soluble in alkalis. Stuffs plunged into this indigo bath get impregnated with the solution, so that when again exposed to the air, the dyeing substance resumes at once its primitive color and insolubility, and washing can carry off only the portions in excess above the intimate combination, or which are merely deposited upon the surface of the stuff.

Such is the result with insoluble coloring matters; but for those which are soluble it should be quite the reverse, since they do not possess an affinity for the organic fibres, which can counterbalance their affinity for water. In such circumstances, the dyer must have recourse to intermediate bodies, which add their affinity for the coloring matter to that possessed by the particles of the stuff, and increase by this twofold action the intimacy and the stability of the combination. These intermediate bodies are the true *mordants*.

Mordants are in general found among the metallic bases or oxydes; whence they might be supposed to be very numerous, like the metals; but as they must unite the twofold condition of possessing a strong affinity for both the coloring matter and the organic fibre, and as the insoluble bases are almost the only ones fit to form insoluble combinations, we may thus perceive that their number may be very limited. It is well known, that although lime and magnesia, for example, have a considerable affinity for coloring particles, and form insoluble compounds with them, yet they cannot be employed as mordants, because they possess no affinity for the textile fibres.

Experience has proved, that of all the bases, those which succeed best as mordants are alumina, tin, and oxyde of iron; the first two of which, being naturally white, are the *only ones which* can be employed for preserving to the color its original tint, at leas without much variation. But whenever the mordant is itself colored, it will cause the dye to take a compound color quite different from its own. If, as is usually said, the mordant enters into a real chemical union with the stuff to be dyed, the application of the mordant should obviously be made in such circumstances as are known to be most favorable to the combination taking place; and this is the principle of every day's practice in the dye-house.

In order that a combination may result between two bodies, they must not only be in contact, but they must be reduced to their ultimate molecules. The mordants that are to be united with stuffs are, as we have seen, insoluble of themselves, for which reason their particles must be divided by solution in an appropriate vehicle. Now this solvent or menstruum will exert in its own favor an affinity for the mordant, which will prove to that extent an obstacle to its attraction for the stuff. Hence we must select such solvents as have a weaker affinity for the mordants than the mordants have for the stuffs. Of all the acids which can be employed to dissolve alumina, for example, vinegar is the one which will retain it with least energy, for which reason the acetate of alumina is now generally substituted for alum, because the acetic acid gives up the alumina with such readiness, that mere elevation of temperature is sufficient to effect the separation of these two substances. Before this substitution of the acetate, alum alone was employed; but without knowing the true reason, all the French dyers preferred the alum of Rome, simply regarding it to be the purest; it is only within these few years that they have understood the real grounds of this preference. This alum has not, in fact, the same composition as the alums of France, England, and Germany, but it consists chiefly of cubic alum having a larger proportion of base. Now this extra portion of base is held by the sulphuric acid more feebly than the rest, and hence is more readily detached in the form of a mordant. Nay, when a solution of cubic alum is heated, this redundant alumina falls down in the state of a subsulphate, long before it reaches the boiling point. This difference had not, however, been recognised, because Roman alum, being usually soiled with ochre on the surface, gives a turbid solution, whereby the precipitate of subsulphate of alumina escaped observation. When the liquid was filtered, and crystallized afresh, common octahedral alum alone was obtained; whence it was most erroneously concluded, that the preference given to Roman alum was unjustifiable, and that its only superiority was in being freer from iron.

Here a remarkable anecdote illustrates the necessity of extreme caution, before we venture to condemn from theory a practice found to be useful in the arts, or set about changing it. When the French were masters in Rome, one of their ablest chemists was sent thither to inspect the different manufactures, and to place them upon a level with the state of chemical knowledge. One of the fabrics, which seemed to him furthest behindhand, was precisely that of alum, and he was particularly hostile to the construction of the furnaces, in which vast boilers received heat merely at their bottoms, and could not be made to boil. He strenuously advised them to be new modelled upon a plan of his own; but, notwithstanding his advice, which was no doubt very scientific, the old routine kept its ground, supported by utility and reputation, and very fortunately, too, for the manufacture; for had the higher heat been given to the boilers, no more genuine cubical alum would have been made, since it is decomposed at a temperature of about 120° F., and common octahedral alum would alone have been produced. The addition of a little alkali to common alum brings it into the same basic state as the alum of Rome.

The two principal conditions, namely, extreme tenuity of particles, and liberty of action, being found in a mordant, its operation is certain. But as the combination to be effected is merely the result of a play of affinity between the solvent and the stuff to be dyed, a sort of partition must take place, proportioned to the mass of the solvent, as well as to its attractive force. Hence the stuff will retain more of the mordant when its solution is more concentrated, that is, when the base diffused through it is not so much protected by a large mass of menstruum; a fact applied to very valuable uses by the practical man. On impregnating in calico printing, for example, different spots of the same web with the same mordant in different degrees of concentration, there is obtained in the dye-bath a depth of color upon these spots intense in proportion to the strength of their various mordants. Thus, with solution of acetate of alumina in different grades of density, and with madder, every shade can be produced, from the fullest red to the lightest pink; and, with acetate of iron and madder, every shade from black to pale violet.

We hereby perceive that recourse must indispensably be had to mordants at different stages of concentration; a circumstance readily realized by varying the proportions of the watery vehicle. See CALICO-PRINTING and MADDER. When these mordants are to be topically applied, to produce partial dyes upon cloth, they must be thickened with starch or gum, to prevent their spreading, and to permit a sufficient body of them to become attached to the stuff. Starch answers best for the more neutral mordants, and gum for the acidulous; but so much of them should never be used, as to impede the attraction of the mordant for the cloth. Nor should the thickened mordants be of too desiccative a nature, lest they become hard, and imprison the chemical agent before it has had an opportunity of combining with the cloth, during the slow evaporation of its water and acid. Hence the mordanted goods, in such a case, should be hung up to dry in a gradual manner, and when oxygen is necessary to the fixation of the base, they should be largely exposed to the atmosphere. The foreman of the factory ought, therefore, to be thoroughly conversant with all the minutiæ of chemical reaction. In cold and damp weather he must raise the temperature of his drying-house, in order to command a more decided evaporation; and when the atmosphere is unusually dry and warm, he should add deliquescent correctives to his thickening, as I have particularized in treating of some styles of calico-printing. But, supposing the application of the mordant and its desiccation to have been properly managed, the operation is by no means complete; nay, what remains to be done is not the least important to success, nor the least delicate of execution. Let us bear in mind that the mordant is intended to combine not only with the organic fibre, but afterwards also with the coloring matter, and that, consequently, it must be laid entirely bare, or scraped clean, so to speak, that is, completely disengaged from all foreign substances which might invest it, and obstruct its intimate contact with the coloring matters. This is the principle and the object of two operations, to which the names of *dunging* and *clearing* have been given.

If the mordant applied to the surface of the cloth were completely decomposed, and the whole of its base brought into chemical union with it, a mere rinsing or scouring in water would suffice for removing the viscid substances added to it, but this never happens, whatsoever precautions may be taken; one portion of the mordant remains untouched, and besides, one part of the base of the portion decomposed does not enter into combination with the stuff, but continues loose and superfluous. All these particles, therefore, must be removed without causing any injury to the dyes. If in this predicament the stuff were merely immersed in water, the free portion of the mordant would dissolve, and would combine indiscriminately with all the parts of the cloth not mordanted, and which should be carefully protected from such combination, as well as the action of the dye. We must therefore add to the scouring water some substance that is capable of seizing the mordant as soon as it is separated from the cloth, and of forming with it an insoluble compound; by which means we shall withdraw it from the sphere of action, and prevent its affecting the rest of the stuff, or interfering with the other dyes. This result is obtained by the addition of cow-dung to the scouring bath; a substance which contains a sufficiently great proportion of soluble animal matters, and of coloring particles, for absorbing the aluminous and ferruginous salts. The heat given to the dung-bath accelerates this combination, and determines an insoluble and perfectly inert coagulum.

Thus the dung-bath produces at once the solution of the thickening paste; a more intimate union between the alumina or iron and the stuff, in proportion to its elevation of temperature, which promotes that union; an effectual subtraction of the undecomposed and superfluous part of the mordant, and perhaps a commencement of mechanical separation of the particles of alumina, which are merely dispersed among the fibres; a separation, however, which can be completed only by the proper scouring, which is done by the dash-wheel with such agitation and pressure (see Bleaching and Dunging) as vastly facilitate the expulsion of foreign particles. See also Bran.

Before concluding this article, we may say a word or two about astringents, and especially gall-nuts, which have been ranked by some writers among mordants. It is rather difficult to account for the part which they play. Of course we do not allude to their operation in the black dye, where they give the well known purple-black color with salts of iron; but to the circumstance of their employment for madder dyes, and especially the Adrianople red. All that seems to be clearly established is, that the astringent principle or tannin, whose peculiar nature in this respect is unknown, combines like mordants with the stuffs and the coloring substance, so as to fix it; but as this tannin has itself a brown tint, it will not suit for white grounds, though it answers quite well for pink grounds. When white spots are desired upon a cloth prepared with oil and galls, they are produced by an oxygenous discharge, effected either through chlorine or chromic acid.

MORDANT is also the name sometimes given to the adhesive matter by which gold-leaf is made to adhere to surfaces of wood and metal in gilding. Paper, vellum, taffety, &c., are easily gilt by the aid of different mordants, such as the following: 1. beer in which some honey and gum arabic have been dissolved; 2. gum arabic, sugar, and water; 3. the viscid juice of onion or hyacinth, strengthened with a little gum arabic. When too much gum is employed, the silver or gold leaf is apt to crack in the drying of the mordant. A little carmine should be mixed with the above colorless liquids, to mark the places where they are applied. The foil is applied by means of a dossil of cotton wool, and when the mordant has become hard, the foil is polished with the same.

The best medium for sticking gold and silver leaf to wood is the following, called *mixtion* by the French artists:—1 pound of amber is to be fused, with 4 ounces of mastic in tears, and 1 ounce of Jewish pitch, and the whole dissolved in 1 pound of linseed oil rendered drying by litharge.

Painters in distemper sometimes increase the effect of their work, by patches of gold leaf, which they place in favorable positions; they employ the above mordant. The manufacturers of paper hangings of the finer kinds attach gold and silver leaf to them by the same varnish.

MOROCCO. See LEATHER.

MORPHIA (*Morphine*, Fr.; *Morphin*, Germ.) is a vegeto-alkali which exists associated with opian, codeine, narcotine, meconine, meconic acid, resin, gum, bassorine, lignine, fat oil, caoutchouc, extractive, &c. in opium. Morphia is prepared as follows: Opium in powder is to be repeatedly digested with dilute muriatic acid, slightly heated, and sea-salt is to be added, to precipitate the opian. The filtered liquid is to be supersaturated with ammonia, which throws down the morphia, along with the meconine, resin, and extractive. The precipitate is to be washed with water, heated, and dissolved in dilute muriatic acid; the solution is to be filtered, whereby the foreign matters are separated from the salt of morphia, which concretes upon cooling, while the meconine remains in the acid liquid. The muriate of morphia having been squeezed between folds of blotting paper, is to be sprinkled with water, again squeezed, next dissolved in water, and decomposed by water of ammonia. The precipitate, when washed, dried, dissolved in alcohol, and crystallized, is morphia.

These crystals, which contain 6·32 per cent. of combined water, are transparent, colorless, four-sided prisms, without smell, and nearly void of taste, fusible at a moderate heat, and they concrete into a radiated translucent mass, but at a higher temperature they grow purple-red. Morphia consists of 72·34 of carbon; 6·366 of hydrogen; 5 of azote; and 16·3 of oxygen. It burns with a red and very smoky flame, is stained red by nitric acid, is soluble in 30 parts of boiling anhydrous alcohol, in 500 parts of boiling water, but hardly if at all in cold water, and is insoluble in ether and oils. The solutions have a strong bitter taste, and an alkaline reaction upon litmus paper. The saline compounds have a bitter taste, are mostly crystallizable, are soluble in water and alcohol (but not in ether), and give a blue color to the peroxyde salts of iron. It is a very poisonous substance. Acetate of morphia is sometimes prescribed, instead of opium, in medicine.

MORTAR, HYDRAULIC, called also *Roman Cement*, is the kind of mortar used for building piers, or walls under or exposed to water, such as those of harbors, docks, &c. The poorer sorts of limestone are best adapted for this purpose, such as contain from 8 to 25 per cent. of foreign matter, in silica, alumina, magnesia, &c. These, though calcined, do not slake when moistened; but if pulverized they absorb water without swelling up or heating, like *fat* lime, and afford a paste which hardens in a few days under water, but in the air they never acquire much solidity. Smeaton first discovered these remarkable facts, and described them in 1759.

The following analyses of different hydraulic limestones, by Berthier, merit confidence:—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
A. *Analyses of limestones.*					
Carbonate of lime - -	97·0	98·5	74·5	76·5	80·0
Carbonate of magnesia - -	2·0	—	23·0	3·0	1·5
Carbonate of protoxyde of iron	—	—	—	3·0	—
Carbonate of manganese -	—	—	—	1·5	—
Silica and alumina - -				15·2	18·0
Oxyde of iron - - -	1·0	1·5	1·2		
	100·0	100·0	100·0	100·0	100·0
B. *Analyses of the burnt lime.*					
Lime - - - - -	96·4	97·2	78·0	68·3	70·0
Magnesia - - - -	1·8	—	20·0	2·0	1·0
Alumina - - - -	1·8	2·8	2·0	24·0	29·0
Oxyde of iron - - -	—	—	—	5·7	—
	100 0	100·0	100·0	100·0	100·0

No. 1 is from the fresh-water lime formation of Chateau-Landon, near Nemours. No. 2, the large-grained limestone of Paris; both of these afford a fat lime when burnt. Dolomite affords a pretty fat lime, though it contains 42 per cent. of carbonate of magnesia; No. 3 is a limestone from the neighborhood of Paris, which yields a poor lime, possessing no hydraulic property; No. 4 is the secondary limestone of Metz; No. 5 is the lime marl of Senonches, near Dreux; both the latter have the property of hardening under water, particularly the last, which is much used at Paris on this account.

All good hydraulic mortars must contain alumina and silica; the oxydes of iron and manganese, at one time considered essential, are rather prejudicial ingredients. By adding silica and alumina, or merely the former, in certain circumstances, to fat lime, a water-cement may be artificially formed; as also by adding to lime any of the following native productions, which contain silicates; puzzolana, trass or tarras, pumice-stone, basalt-tuff, slate-clay. Puzzolana is a volcanic product, which forms hills of considerable extent to the south-west of the Appenines, in the district of Rome, the Pontine marshes, Viterbo, Bolsena, and in the Neapolitan region of Puzzuolo, whence the name. A similar volcanic tufa is found in many other parts of the world. According to Berthier, the Italian puzzolana consists of 44·5 silica; 15·0 alumina; 8·8 lime; 4·7 magnesia; 1·4 potash; 4·1 soda; 12 oxydes of iron and titanium; 9·2 water; in 100 parts.

The *tufa* stone, which when ground forms *trass*, is composed of 57·0 silica, 16·0 clay, 2·6 lime, 1·0 magnesia, 7·0 potash, 1·0 soda, 5 oxydes of iron and titanium, 9·6 water. This tuff is found abundantly filling up valleys in beds of 10 or 20 feet deep, in the north of Ireland, among the schistose formations upon the banks of the Rhine, and at Monheim in Bavaria.

The fatter the lime, the less of it must be added to the ground puzzolana or trass, to form a hydraulic mortar; the mixture should be made extemporaneously, and must at any rate be kept dry till about to be applied. Sometimes a proportion of common sand mortar instead of lime is mixed with the trass. When the hydraulic cement hardens too soon, as in 12 hours, it is apt to crack; it is better when it takes 8 days to concrete. Through the agency of the water, silicates of lime, alumina, (magnesia,) and oxyde of iron are formed, which assume a stony hardness.

Besides the above two volcanic products, other native earthy compounds are used in making water cements. To this head belong all limestones which contain from 20 to 30 per cent. of clay and silica. By gentle calcination, a portion of the carbonic acid is expelled, and a little lime is combined with the clay, while a silicate of clay and lime results, associated with lime in a subcarbonated state. A lime-marl containing less clay will bear a stronger calcining heat without prejudice to its qualities as a hydraulic cement; but much also depends upon the proportion of silica present, and the physical structure of all the constituents.

The mineral substance most used in England for making such mortar is vulgarly called *cement-stone.* It is a reniform limestone, which occurs distributed in single nodules or rather lenticular cakes, in beds of clay. They are mostly found in those argillaceous strata which alternate with the limestone beds of the oolite formation, as also in the clay strata above the chalk, and sometimes in the London clay. On the coasts of Kent, in the isles of Sheppey and Thanet, on the coasts of Yorkshire, Somersetshire, and the Isle of Wight, &c., these nodular concretions are found in considerable quantities, having been laid bare by the action of the sea and weather. They were called by the older mineralogists *Septaria* and *Ludus Helmontii* (Van Helmont's coits.) When sawn across, they show veins of calc-spar traversing the silicious clay, and are then sometimes placed in the cabinets of *virtuosi.* They are found also in several places on the Continent, as at Neustadt-Eberswalde, near Antwerp, near Altdorf in Bavaria; as also at Boulogne-sur-mer, where they are called Boulogne-pebbles (*galets*). These nodules vary in size from that of a fist to a man's head; they are of a yellow-gray or brown color, interspersed with veins of calc-spar, and sometimes contain cavities bestudded with crystals.

Their specific gravity is 2·59.

Analyses of several cement-stones, and of the cement made with them:—

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
A. *Constituents of the cement-stones.*					
Carbonate of lime - -	65·7	61·6	–	82·9	63·8
— magnesia - -	0·5	–	–	–	1·5
— protoxyde of iron -	6·0	6·0	–	4·3	11·6
— manganese - -	1·6	–	–		
Silica - - - -	18·0	15·0	–	13·0	14·0
Alumina or clay - - -	6·6	4·8	–	trace	5·7

Analyses of several cement-stones, &c.—*Continued.*

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Oxyde of iron - - :	–	3·0			
Water - - - :	1·2	6·6	–	–	3·4
B. *Constituents of the Cement.*					
Lime - - - -	55·4	54·0	55·0	–	56·6
Magnesia - - -	–	–	–	–	1·1
Alumina or clay - - -	36·0	31·0	38·0	–	21·0
Oxyde of iron - - -	8·6	15·0	13·0	–	13·7

No. 1. English cement-stone, analyzed by Berthier; No. 2. Boulogne stone, by Drapiez; No. 3. English ditto, by Davy; No. 4. reniform limestone nodules from Arkona, by Hühnefeld; No. 5. cement-stone of Avallon, by Dumas.

In England the stones are calcined in shaft-kilns, or sometimes in mound-kilns, then ground, sifted, and packed in casks. The color of the powder is dark-brown-red. When made into a thick paste with water, it absorbs little of it, evolves hardly any heat, and soon indurates. It is mixed with sharp sand in various proportions, immediately before using it; and is employed in all marine and river embankments, for securing the seams of stone or brick floors or arches from the percolation of moisture, and also for facing walls to protect them from damp.

The cement of Pouilly is prepared from a Jurassic (secondary) limestone, which contains 39 per cent. of silica, with alumina, magnesia, and iron oxyde. Vicat forms a factitious Roman cement by making bricks with a pasty mixture of 4 parts of chalk, and 1 part of dry clay, drying, burning, and grinding them. River sand must be added to this powder; and even with this addition, its efficacy is somewhat doubtful; though it has, for want of a better substitute, been much employed at Paris.

The cement of Dihl consists of porcelain or salt-glaze potsherds ground fine, and mixed with boiled linseed oil.

Hamelin's mastic or lithic paint to cover the façades of brick buildings, &c., is composed of 50 measures of silicious sand, 50 of lime-marl, and 9 of litharge or red-lead ground up with linseed oil.

MOSAIC GOLD. For the composition of this peculiar alloy of copper and zinc, called also *Or-molu*, Messrs. Parker and Hamilton obtained a patent in November, 1825. Equal quantities of copper and zinc are to be "melted at the lowest temperature that copper will fuse," which being stirred together so as to produce a perfect admixture of the metals, a further quantity of zinc is added in small portions, until the alloy in the melting pot becomes of the color required. If the temperature of the copper be too high, a portion of the zinc will fly off in vapor, and the result will be merely spelter or hard solder; but if the operation be carried on at as low a heat as possible, the alloy will assume first a brassy yellow color; then, by the introduction of small portions of zinc, it will take a purple or violet hue, and will ultimately become perfectly white; which is the appearance of the proper compound in its fused state. This alloy may be poured into ingots; but as it is difficult to preserve its character when re-melted, it should be cast directly into the figured moulds. The patentees claim the exclusive right of compounding a metal consisting of from 52 to 55 parts of zinc out of 100.

Mosaic gold, the *aurum musivum* of the old chemists, is a sulphuret of tin.

MOSAIC. (*Mosaïque*, Fr.; *Mosaisch*, Germ.) There are several kinds of mosaic, but all of them consist in imbedding fragments of different colored substances, usually glass or stones, in a cement, so as to produce the effect of a picture. The beautiful chapel of Saint Lawrence in Florence, which contains the tombs of the Medici, has been greatly admired by artists, on account of the vast multitude of precious marbles, jaspers, agates, avanturines, malachites, &c., applied in mosaic upon its walls. The detailed discussion of this subject belongs to a treatise upon the fine arts.

MOTHER OF PEARL (*Nacre de Perles*, Fr.; *Perlen mutter*, Germ.) is the hard, silvery, brilliant internal layer of several kinds of shells, particularly oysters, which is often variegated with changing purple and azure colors. The large oysters of the Indian seas alone secrete this coat of sufficient thickness to render their shells available to the purposes of manufactures. The genus of shell fish called *pentadina* furnishes the finest pearls, as well as mother of pearl; it is found in greatest perfection round the coasts of Ceylon, near Ormus in the Persian Gulf, at Cape Comorin, and among some of the Australian seas. The brilliant hues of mother of pearl do not depend upon the nature of the substance, but upon its structure. The microscopic wrinkles or furrows which run across the surface of every slice, act upon the reflected light in such a way as to produce the chromatic effect; for Sir David Brewster has shown, that if we take, with very fine black wax, or with the fusible alloy of D'Arcet, an impression of mother of pearl, it will possess the iridescent appearance. Mother of pearl is very delicate to work, but it may be fashioned by saws, files, and drills, with the aid sometimes of a corrosive acid, such as the dilute sulphuric or muriatic; and it is polished by colcothar of vitriol.

MOTHER-WATER is the name of the liquid which remains after all the salts that will regularly crystallize have been extracted, by evaporation and cooling, from any saline solution.

MOUNTAIN SOAP (*Savon de montagne*, Fr.; *Bergseife*, Germ.) is a tender mineral, soft to the touch, which assumes a greasy lustre when rubbed, and falls to pieces in water. It consists of silica 44, alumina 26·5, water 20·5, oxyde of iron 8, lime 0·5. It occurs in beds, alternating with different sorts of clay, in the Isle of Skye, at Billin in Bohemia, &c. It has been often, but improperly, confounded with steatite.

MUCIC ACID (*Acide mucique*, Fr.; *Schleimsaüre*, Germ.) is the same as the saclactic acid of Scheele, and may be obtained by digesting one part of gum arabic, sugar of milk, or pectic acid, with twice or thrice their weight of nitric acid. It forms white granular crystals, and has not been applied to any use in the arts.

MUCILAGE is a solution in water of gummy matter of any kind.

MUFFLE is the earthenware case or box, in the assay furnaces, for receiving the cupels, and protecting them from being disturbed by the fuel. See ASSAY and FURNACE.

MUNDIC is the name of copper pyrites among English miners.

MUNJEET is a kind of madder grown in several parts of India.

MURIATIC or HYDROCHLORIC ACID; anciently *marine acid*, and *spirit of salt*. (*Acide hydrochlorique*, and *Chlorhydrique*, Fr.; *Salzsaüre*, Germ.) This acid is now extracted from sea-salt, by the action of sulphuric acid and a moderate heat; but it was originally obtained from the salt by exposing a mixture of it and of common clay to ignition in an earthen retort. The acid gas which exhales, is rapidly condensed by water. 100 cubic inches of water are capable of absorbing no less than 48,000 cubic inches of the acid gas, whereby the liquid acquires a specific gravity of 1·2109; and a volume of 142 cubic inches. This vast condensation is accompanied with a great production of heat, whence it becomes necessary to apply artificial refrigeration, especially if so strong an acid as the above is to be prepared. In general, the muriatic acid of commerce has a specific gravity varying from 1·15 to 1·20; and contains, for the most part, considerably less than 40 parts by weight of acid gas in the hundred. The above stronger acid contains 42·68 per cent. by weight; for since a cubic inch of water, which weighs 252·5 grains, has absorbed 480 cubic inches = 188 grains of gas; and 252·5 + 188 = 440·5; then 440·5 : 188 : : 100 : 42·68. In general a very good approximation may be found to the per centage of real muriatic acid, in any liquid sample, by multiplying the decimal figures of the specific gravity by 200. Thus for example, at 1·162 we shall have by this rule 0·162 × 200 = 32·4, for the quantity of gas in 100 parts of the liquid. Muriatic acid gas consists of chlorine and hydrogen combined, without condensation, in equal volumes. Its specific gravity is 1·247, air = 1·000.

By sealing up muriate of ammonia and sulphuric acid, apart, in a strong glass tube recurved, and then causing them to act on each other, Sir H. Davy procured liquid muriatic acid. He justly observes, that the generation of elastic substances in close vessels, either with or without heat, offers much more powerful means of approximating their molecules than those dependant on the application of cold, whether natural or artificial; for as gases diminish only $\frac{1}{480}$ in volume for every degree of Fahrenheit's scale, beginning at ordinary temperatures, a very slight condensation only can be produced by the most powerful freezing mixtures, not half as much as would result from the application of a strong flame to one part of a glass tube, the other part being of ordinary temperature; and when attempts are made to condense gases into liquids by sudden mechanical compression, the heat instantly generated presents a formidable obstacle to the success of the experiment; whereas in the compression resulting from their slow generation in close vessels, if the process be conducted with common precautions, there is no source of difficulty or danger; and it may be easily assisted by artificial cold, in cases where gases approach near to that point of compression and temperature at which they become vapors.—*Phil. Trans.* 1823.

The muriatic acid of commerce has usually a yellowish tinge, but when chemically pure it is colorless. It fumes strongly in the air, emitting a corrosive vapor of a peculiar smell. The characteristic test of muriatic acid in the most dilute state, is nitrate of silver, which causes a curdy precipitate of chloride of silver.

The preparation of this acid upon the great scale is frequently effected in this country by acting upon sea-salt in hemispherical iron pots, or in cast-iron cylinders, with concentrated sulphuric acid; taking 6 parts of the salt to 5 of the acid. The mouth of the pot may be covered with a slab of silicious freestone, perforated with two holes of about *two inches diameter* each, into the one of which the acid is poured by a funnel in successive portions, and into the other, a bent glass, or stone-ware tube, is fixed, for conducting the disengaged muriatic gas into a series of large globes of bottle glass, one third filled with water, and laid on a sloping sand-bed. A week is commonly employed for working off each pot; no heat being applied to it till the second day.

The decomposition of sea-salt by sulphuric acid, was at one time carried on by some French manufacturers in large leaden pans, 10 feet long, 5 feet broad, and a foot deep, covered with sheets of lead, and luted. The disengaged acid gas was made to circulate in a conduit of glazed bricks, nearly 650 yards long, where it was condensed by a sheet of water exceedingly thin, which flowed slowly in the opposite direction of the gas down a slope of 1 in 200. At the end of this canal nearest the apparatus, the muriatic acid was as strong as possible, and pretty pure; but towards the other end, the water was hardly acidulous. The condensing part of this apparatus was therefore tolerably complete; but as the decomposition of the salt could not be finished in the leaden pans, the acid mixture had to be drawn out of them, in order to be completely decomposed in a reverberatory furnace; in this way nearly 50 per cent. of the muriatic acid was lost. And besides, the great quantity of gas given off during the emptying of the lead-chambers was apt to suffocate the workmen, or seriously injured their lungs, causing severe hemoptysis. The employment of muriatic acid is so inconsiderable, and the loss of it incurred in the preceding process is of so little consequence, that subsequently, both in France and in England, sulphate of soda, for the soda manufacture, has been procured with the dissipation of the muriatic acid in the air. In the method more lately resorted to, the gaseous products are discharged into extensive vaults, where currents of water condense them and carry them off into the river. The surrounding vegetation is thereby saved in some measure from being burned up, an accident which was previously sure to happen when fogs precipitated the floating gases upon the ground. At Newcastle, Liverpool, and Marseilles, where the consumption of muriatic acid bears no proportion to the manufacture of soda, this process is now practised upon a vast scale.

The apparatus for condensing muriatic acid gas has been modified and changed, of late years, in many different ways.

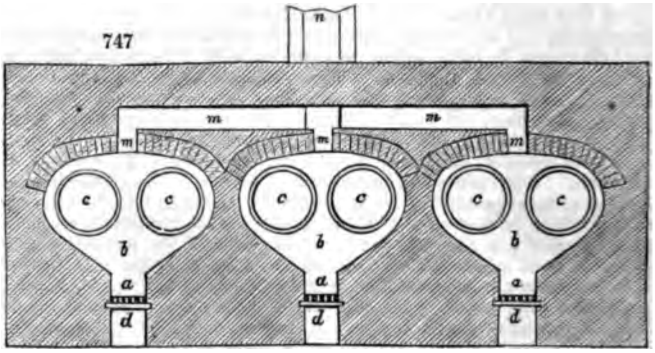
The Bastringue apparatus. At the end of a reverberatory furnace, (see COPPER, SMELTING OF, and SODA, MANUFACTURE OF,) a rectangular lead trough or pan, about 1 foot deep, of a width equal to that of the interior of the furnace, that is, about 5 feet wide, and 6½ feet long, is incased in masonry, having its upper edges covered with cast-iron plates or fire tiles, and placed upon a level with the passage of the flame, as it escapes from the reverberatory. The arch which covers that pan forms a continuation of the roof of the reverberatory, and is of the same height. The flame which proceeds from the furnace containing the mixture of salt and sulphuric acid is made to escape between the vault and the surface of the iron plates or fire tiles, through a passage only 4 inches in height. When the burned air and vapors reach the extremity of the pan, they are reflected downwards, and made to return beneath the bottom of the pan, in a flue, which is afterwards divided so as to lead the smoke into two lateral flues, which terminate in the chimney. The pan is thus surrounded as it were with the heat and flame discharged from the reverberatory furnace. See EVAPORATION. A door is opened near the end of the pan, for introducing the charge of sea-salt, amounting to 12 bags of 2 cwts. each, or 24 cwts. This door is then luted on as tightly as possible, and for every 100 parts of salt, 110 of sulphuric acid are poured in, of specific gravity 1·594, containing 57 per cent. of dry acid. This acid is introduced through a funnel inserted in the roof of the furnace. Decomposition ensues, muriatic acid gas mingled with steam is disengaged, and is conducted through 4 stone-ware tubes into the refrigerators, where it is finally condensed. These refrigerators consist of large stone-ware carboys, called *dame-jeans* in France, to the number of 7 or 8 for each pipe, and arranged so that the neck of the one communicates with the body of the other; thus the gas must traverse the whole series, and gets in a good measure condensed by the water in them, before reaching the last.

When the operation is finished, the door opposite the pan is opened, and the residuum as it is discharged, in the form of a fluid magma, upon a square bed of bricks, exterior to the furnace. This paste speedily concretes on cooling, and is then broken into fragments and carried to the soda manufactory. The immense quantity of gas exhaled in discharging the pan, renders this part of the operation very painful to the workmen; and wasteful in reference to the production of muriatic acid. The difficulty of luting securely the cast-iron plates or fire tiles which cover the pan, the impossibility of completing the decomposition of the salt, since the residuum must be run off in a liquid state, finally, the damage sustained by the melting and corrosion of the lead, &c., are among the causes why no more than 80 or 90 parts of muriatic acid at 1·170 are collected, equivalent to 25 per cent. of real acid for every 100 of salt employed, instead of much more than double that quantity, which it may be made to yield by a well-conducted chemical process.

The cylinder apparatus is now much esteemed by many manufacturers. *Fig.* 747

represents, in transverse section, a bench of iron cylinder retorts, as built up in a proper furnace for producing muriatic acid; and *fig.* 748 a longitudinal section of one retort with one of its carboys of condensation. *a* is the grate; *b*, a fireplace, in which two iron cylinders, *c c*, are set alongside of each other. They are 5½ feet long, 20 inches in diameter, about ½ of an inch thick, and take 1·6 cwts. of salt for a charge; *d* is the ash-pit; *e*, *e*, are cast-iron lids, for closing both ends of the cylinders; *f* is a tube in the posterior lid, for pouring in the sulphuric acid; *g* is another tube, in the anterior lid, for the insertion of the bent pipe of hard glazed stone-ware *h*; *i* is a three-necked stone-ware carboy; *k* is a tube of safety; *l*, a tube of communication with the second carboy; *m m*, *m m*, are the flues leading to the chimney *n*.

747



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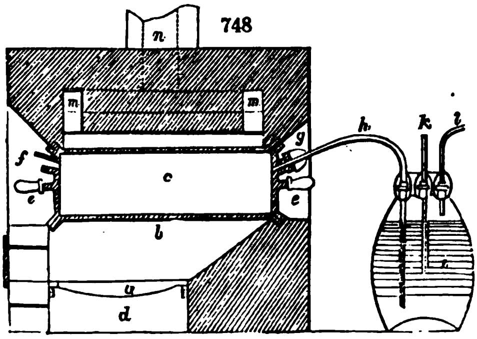

After the salt has been introduced, and the fire kindled, 83½ per cent. of its weight of sulphuric acid, of spec. grav. 1·80, should be slowly poured into the cylinder through a lead funnel, with a syphon-formed pipe. The three-necked carboys may be either placed in a series for each retort, like a range of Woulfe's bottles, or all the carboys of the front range may be placed in communication with one another, while the last carboy at one end is joined to the first of the second range; and thus in succession. They must be half filled with cold water; and when convenient, those of the front row at least, should be plunged in an oblong trough of running water. The acid which condenses in the carboys of that row is apt to be somewhat contaminated with sulphuric acid, muriate of iron, or even sulphate of soda; but that in the second and third will be found to be pure. In this way 100 parts of sea-salt will yield 130 parts of muriatic acid, of spec. grav. 1·19; while the sulphate of soda in the retort will afford from 208 to 210 of that salt in crystals.

It is proper to heat all the parts of the cylinders equably, to ensure the simultaneous decomposition of the salt, and to protect it from the acid; for the hotter the iron, and the stronger the acid, the less erosion ensues.

Some manufacturers, with the view of saving fuel by the construction of their furnaces, oppose to the flame as many obstacles as they can, and make it perform numerous circulations round the cylinders; but this system is bad, and does not even effect the desired economy, because the passages, being narrow, impair the draught, and become speedily choked up with the soot, which would be burned profitably in a freer space; the decomposition also, being unequally performed, is less perfect, and the cylinders are more injured. It is better to make the flame envelope at once the body of the cylinder; after which it may circulate beneath the vault, in order to give out a portion of its caloric before it escapes at the chimney.

The fire should be briskly kindled, but lowered as soon as the distillation commences; and then continued moderate till the evolution of gas diminishes, when it must be heated somewhat strongly to finish the decomposition. The iron door is now removed, to extract the sulphate of soda, and to recommence another operation. This sulphate ought to be white and uniform, exhibiting in its fracture no undecomposed sea-salt.

Liquid muriatic acid has a very sour corrosive taste, a pungent suffocating smell, and acts very powerfully upon a vast number of mineral, vegetable, and animal substances. It is much employed for making many metallic solutions; and in combination with nitric acid, it forms the aqua regia of the alchemists, so called from its property of dissolving gold.

Table of Muriatic Acid, by Dr. Ure.

Acid of 120 in 100	Specific gravity.	Chlorine.	Muriatic Gas.	Acid of 120 in 100	Specific gravity.	Chlorine.	Muriatic Gas.	Acid of 120 in 100	Specific gravity.	Chlorine.	Muriatic Gas.
100	1·2000	39·675	40·777	66	1·1328	26·186	26·913	32	1·0637	12·697	13·049
99	1·1982	39·278	40·369	65	1·1308	25·789	26·505	31	1·0617	12·300	12·641
98	1·1964	38·882	39·961	64	1·1287	25·392	26·098	30	1·0597	11·903	12·233
97	1·1946	38·485	39·554	63	1·1267	24·996	25·690	29	1·0577	11·506	11·825
96	1·1928	38·089	39·146	62	1·1247	24·599	25·282	28	1·0557	11·109	11·418
95	1·1910	37·692	38·738	61	1·1226	24·202	24·874	27.	1·0537	10·712	11·010
94	1·1893	37·296	38·330	60	1·1206	23·805	24·466	26	1·0517	10·316	10·602
93	1·1875	36·900	37·923	59	1·1185	23·408	24·058	25	1·0497	9·919	10·194
92	1·1857	36·503	37·516	58	1·1164	23·012	23·050	24	1·0477	9·522	9·786
91	1·1846	36·107	37·108	57	1·1143	22·615	23·242	23	1·0457	9·126	9·379
90	1·1822	35·707	36·700	56	1·1123	22·218	22·834	22	1·0437	8·729	8·971
89	1·1802	35·310	36·292	55	1·1102	21·822	22·426	21	1·0417	8·332	8·563
88	1·1782	34·913	35·884	54	1·1082	21·425	22·019	20	1·0397	7·935	8·155
87	1·1762	34·517	35·476	53	1·1061	21·028	21·611	19	1·0377	7·538	7·747
86	1·1741	34·121	35·068	52	1·1041	20·632	21·203	18	1·0357	7·141	7·340
85	1·1721	33·724	34·660	51	1·1020	20·235	20·796	17	1·0337	6·745	6·932
84	1·1701	33·328	34·252	50	1·1000	19·837	20·388	16	1·0318	6·348	6·524
83	1·1681	32·931	33·845	49	1·0980	19·440	19·980	15	1·0298	5·951	6·116
82	1·1661	32·535	33·437	48	1·0960	19·044	19·572	14	1·0279	5·554	5·709
81	1·1641	32·136	33·029	47	1·0939	18·647	19·165	13	1·0259	5·158	5·301
80	1·1620	31·746	32·621	46	1·0919	18·250	18·757	12	1·0239	4·762	4·893
79	1·1599	31·343	32·213	45	1·0899	17·854	18·349	11	1·0220	4·365	4·486
78	1·1578	30·946	31·805	44	1·0879	17·457	17·941	10	1·0200	3·968	4·078
77	1·1557	30·550	31·398	43	1·0859	17·060	17·534	9	1·0180	3·571	3·670
76	1·1536	30·153	30·990	42	1.0838	16·664	17·126	8	1·0160	3·174	3·262
75	1·1515	29·757	30·582	41	1·0818	16·267	16·718	7	1·0140	2·778	2·854
74	1·1494	29·361	30·174	40	1·0798	15·870	16·310	6	1·0120	2·381	2·447
73	1·1473	28·964	29·767	39	1·0778	15·474	15·902	5	1·0100	1·984	2·039
72	1·1452	28·567	29·359	38	1·0758	15·077	15·494	4	1·0080	1·588	1·631
71	1·1431	28·171	28·951	37	1·0738	14·680	15·087	3	1·0060	1·191	1·224
70	1·1410	27·772	28·544	36	1·0718	14·284	14·679	2	1·0040	0·795	0·816
69	1·1389	27·376	28·136	35	1·0697	13·887	14·271	1	1·0020	0·397	0·408
68	1·1369	26·979	27·728	34	1·0677	13·490	13·863				
67	1·1349	26·583	27·321	33	1·0657	13·094	13·456				

MURIATES were, till the great chemical era of Sir H. Davy's researches upon chlorine, considered to be compounds of an undecompounded acid, the muriatic, with the different bases; but he proved them to be in reality compounds of chlorine with the metals. They are all, however, still known in commerce by their former appellation. The only muriates much used in the manufactures are, *Muriate of ammonia*, or SAL AMMONIAC; *muriated peroxyde of mercury*, MERCURY, *bichloride of; muriate of soda*, or *chloride of sodium*, see SALT; *muriate of tin*, see CALICO-PRINTING and TIN.

MUSK (*Musc*, Fr.; *Moschus*, Germ.) is a peculiar aromatic substance, found in a sac between the navel and the parts of generation of a small male quadruped of the deer kind, called by Linnæus, Moschus moschiferus, which inhabits Tonquin and Thibet. The color of musk is blackish-brown; it is lumpy or granular, somewhat like dried blood, with which substance, indeed, it is often adulterated. The intensity of its smell is almost the only criterion of its genuineness. When thoroughly dried it becomes nearly scentless; but it recovers its odor when slightly moistened with water of ammonia. The Tonquin musk is most esteemed. It comes to us in small bags covered with a reddish-brown hair; the bag of the Thibet musk is covered with a silver-gray hair. All the analyses of musk hitherto made teach little or nothing concerning its active or essential constituent. It is used in medicines, and is an ingredient in a great many perfumes.

MUSLIN is a fine cotton fabric, used for ladies' robes; which is worn either white, dyed, or printed.

MUST is the sweet juice of the grape.

MUSTARD (*Moutarde*, Fr.; *Senf*, Germ.) is a plant which yields the well-known seed used as a condiment to food. M. Lenormand gives the following prescription for preparing mustard for the table.

With 2 pounds of very fine flour of mustard, mix half an ounce of each of the following fresh plants; parsley, chervil, celery, and tarragon, along with a clove of garlic, and twelve salt anchovies, all well minced. The whole is to be triturated with the flour of mustard till the mixture becomes uniform. A little grape-must or sugar is to be added, to give the requisite sweetness; then one ounce of salt, with sufficient water to form a thinnish paste by rubbing in a mortar. With this paste the mustard pots being nearly filled, a redhot poker is to be thrust down into the contents of each, which removes (it is said) some of the acrimony of the mustard, and evaporates a little water, so as to make room for pouring a little vinegar upon the surface of the paste. Such table mustard not only keeps perfectly well, but improves with age.

The mode of preparing table mustard patented by M. Soyés, consisted in steeping mustard seed in twice its bulk of weak wood vinegar for eight days, then grinding the whole into paste in a mill, putting it into pots, and thrusting a redhot poker into each of them.

MUTAGE is a process used in the south of France to arrest the progress of fermentation in the must of the grape. It consists either in diffusing sulphurous acid, from burning sulphur matches in the cask containing the must, or in adding a little sulphite (not sulphate) of lime to it. The last is the best process. See FERMENTATION.

MYRICINE is a vegetable principle which constitutes from 20 to 30 per cent. of the weight of bees-wax, being the residuum from the solvent action of alcohol upon that substance. It is a grayish-white solid, which may be vaporized almost without alteration.

MYRRH is a gum-resin, which occurs in tears of different sizes; they are reddish-brown, semi-transparent, brittle, of a shining fracture, appear as if greasy under the pestle, they have a very acrid and bitter taste, and a strong, not disagreeable, smell. Myrrh flows from the incisions of a tree not well known, which grows in Arabia and Abyssinia, supposed to be a species of *amyris* or *mimosa*. It consists of resin and gum in proportions stated by Pelletier at 31 of the former and 66 of the latter; but by Braconot, at 23 and 77. It is used only in medicine.

N.

NACARAT is a term derived from the Spanish word *nacar*, which signifies mother of pearl; and is applied to a pale red color, with an orange cast. See CALICO-PRINTING. The *nacarat* of Portugal or *Bezetta* is a crape or fine linen fabric, dyed fugitively of the above tint, which ladies rub upon their countenances to give them a roseate hue. The Turks of Constantinople manufacture the brightest red crapes of this kind. See ROUGE.

NAILS, MANUFACTURE OF. (*Clou*, Fr.; *Nagel*, Germ.)

The forging of nails was till of late years a handicraft operation, and therefore belonged to a book of trades, rather than to a dictionary of arts. But several combinations of machinery have been recently employed, under the protection of patents, for making these useful implements, with little or no aid of the human hand; and these deserve to be noticed, on account both of their ingenuity and importance.

As nails are objects of prodigious consumption in building their block-houses, the citizens of the United States very early turned their mechanical genius to good account in the construction of various machines for making them. So long since as the year 1810, it appears, from the report of the secretary of their treasury, that they possessed a machine which performed the cutting and heading at one operation, with such rapidity that it could turn out upwards of 100 nails per minute. "Twenty years ago," says the secretary of the state of Massachusetts, in that report, "some men, then unknown, and then in obscurity, began by cutting slices out of old hoops, and, by a common vice griping these pieces, headed them with several strokes of the hammer. By progressive improvements, slitting-mills were built, and the shears and the heading tools were perfected; yet much labor and expense were requisite to make nails. In a little time Jacob Perkins, Jonathan Ellis, and a few others, put into execution the thought of cutting and of heading nails by water power; but, being more intent upon their machinery than upon their pecuniary affairs, they were unable to prosecute the business. At different times other men have spent fortunes in improvements and it may be said with truth that more than one million of dollars has been expended; but at length these joint efforts are crowned with complete success, and we are now able to manufacture, at about one third of the expense that wrought nails can be manufactured for, nails which are superior to them for at least three fourths of the purposes to which nails are applied, and for most of those purposes they are full as good. The machines made use of by Odiorne, those invented by Jonathan Ellis, and a few others, present very fine specimens of American genius.

"To northern carpenters, it is well known that in almost all instances it is unnecessary to bore a hole before driving a cut nail; all that is requisite is, to place the cutting edge of the nail across the grain of the wood; it is also true, that cut nails will hold better in the wood. These qualities are, in some rough building works, worth twenty *per cent.* of the value of the article, which is equal to the whole expense of manufacturing. For sheathing and drawing, cut nails are full as good as wrought nails; only in one respect are the best wrought nails a little superior to cut nails, and that is where it is necessary they should be clinched. The manufacture of cut nails was born in our country, and has advanced, within its bosom, through all the various stages of infancy to manhood; and no doubt we shall soon be able, by receiving proper encouragement, to render them superior to wrought nails in every particular.

"The principal business of rolling and slitting-mills, is rolling nail plates; they also serve to make nail rods, hoops, tires, sheet iron, and sheet copper. In this State we have not less than twelve.

"These mills could roll and slit 7000 tons of iron a year; they now, it is presumed, roll and slit each year about 3500 tons, 2400 tons of which, probably, are cut up into nails and brads, of such a quality that they are good substitutes for hammered nails, and, in fact, have the preference with most people, for the following reasons; viz., on account of the sharp corner and true taper with which cut nails are formed; they may be driven into harder wood without bending or breaking, or hazard of splitting the wood, by which the labor of boring is saved, the nail one way being of the same breadth or thickness from head to point."

Since the year 1820, the following patents have been obtained in England for making nails; many of them of American origin:—

Alexander Law, September, 1821, for nails and bolts for ships' fastenings, made in a twisted form, by hand labor.

Glascott and Mitchell, December, 1823, for ship nails with rounded heads, by hand labor.

Wilks and Ecroyd, November, 1825, for an engine for cutting wedge-form pieces from plates.

Ledsom and Jones, December 11, 1827, for machinery for cutting brads and sprigs from plates; it does not form heads.

The first nail apparatus to which I shall particularly advert, is due to Dr. Church; it was patented in his absence by his correspondent, Mr. Thomas Tyndall, of Birmingham, in December, 1827. It consists of two parts; the first is a mode of forming nails, and the shafts of screws, by pinching or pressing ignited rods of iron between indented rollers; the second produces the threads on the shafts of the screws previously pressed. The metallic rods, by being passed between a pair of rollers, are rudely shaped, and then cut asunder between a pair of shears; after which they are pointed and headed, or otherwise brought to their finished forms, by the agency of dies placed in a revolving cylinder. The several parts of the mechanism are worked by toothed wheels, cams, and levers. The second part of Dr. Church's invention consists of a mechanism for cutting the threads of screws to any degree of obliquity or form.*

Mr. L. W. Wright's (American) apparatus should have been mentioned before the preceding, as the patent for it was sealed in March of the same year; though an amended patent was obtained in September, 1828. Its object was to form metal screws for wood. I have seen the machinery, but consider it much too complex to be described in the present work.

Mr. Edward Hancorne, of Skinner street, London, nail manufacturer, obtained a patent in October, 1828, for a nail making-machine, of which a brief description may give my readers a conception of this kind of manufacture. Its principles are similar to those of Dr. Church's more eleborate apparatus.

The rods or bars having been prepared in the usual way, either by rolling or hammering, or by cutting from sheets or plates of iron, called slitting, are then to be made red-hot, and in that state passed through the following machine, whereby they are at once cut into suitable lengths, pressed into wedge forms for pointing at the one end, and stamped at the other end to produce the head. A longitudinal view of the machine is shown in *fig.* 749. A strong iron frame-work, of which one side is shown at *a a*, supports the whole of the mechanism. *b* is a table capable of sliding to and fro horizontally. Upon this table are the clamps, which lay hold of the sides of the rod as it advances: as also the shears which cut the rod into nail lengths.

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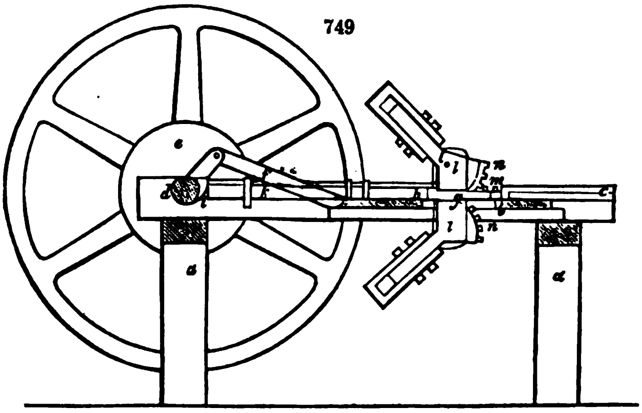
* For further details, see Newton's Journal, 2d series, vol iii. p. 184.

749



These clamps or holders consist of a fixed piece and a moveable piece; the latter being brought into action by a lever. The rod or bar of iron shown at *c*, having been made redhot, is introduced into the machine by sliding it forward upon the table *b*, when the table is in its most advanced position; rotatory motion is then given to the crank shaft *d*, by means of a band passing round the rigger pulley *e*, which causes the table *b* to be drawn back by the crank rod *f*: and as the table recedes, the horizontal lever is acted upon, which closes the clamps. By these means the clamps take fast hold of the sides of the heated rod, and draw it forward, when the moveable chap of the shears, also acted upon by a lever, slides laterally, and cuts off the end of the rod held by the clamps: the piece thus separated is destined to form one nail.

Suppose that the nail placed at *g*, having been thus brought into the machine and cut off, is held between clamps, which press it sideways (these clamps are not visible in this view); in this state it is ready to be headed and pointed.

The *header* is a steel die *h*, which is to be pressed up against the end of the nail by a cam *i*, upon the crank-shaft; which cam, at this period of the operation, acts against the end of a rod *k*, forming a continuation of the die *h*, and forces up the die, thus compressing the metal into the shape of a nail-head.

The *pointing* is performed by two rolling snail pieces or spirals *l*, *l*. These pieces are somewhat broader than the breadth of the nail; they turn upon axles in the side frames. As the table *b* advances, the racks *m*, on the edge of this table, take into the toothed segments *n*, *n*, upon the axles of the spirals, and cause them to turn round.

These spirals pinch the nail at first close under its head with very little force; but as they turn round, the longer radius of the spiral comes into operation upon the nail, so as to press its substance very strongly, and squeeze it into a wedge form. Thus the nail is completed, and is immediately discharged from the clamps or holders. The carriage is then again put in motion by the rotation of the crank-shaft, which brings another portion of the rod *c* forward, cuts it off, and then forms it into a nail.

Richard Prosser, July, 1831, for making tacks for ornamental furniture, by soldering or wedging the spike into the head. This also is the invention of Dr. Church.

Dr. William Church, February, 1832, for improvements in machinery for making nails. These consist, first, in apparatus for forming rods, bars, or plates of iron, or other metals; secondly, in apparatus for converting the rods, &c., into nails; thirdly, in improvements upon Prosser's patent. The machinery consists in laminating rollers, and compressing dies.

The method of forming the rods from which the nails are to be made, is very advantageous. It consists in passing the bar or plate iron through pressing rollers, which have indentations upon the peripheries of one or both of them, so as to form the bar or plate into the required shape for the rods, which may be afterwards separated into rods of any desired breadth, by common slitting rollers.

The principal object of rolling the rods into these wedge forms, is to measure out a quantity of metal duly proportioned to the required thickness or strength of the nail in its several parts; which quantity corresponds to the indentations of the rollers.

Thomas John Fuller, February 27, 1834, for an improved apparatus for making square-pointed, and also flat-pointed nails. He claims as his invention, the application of vertical and horizontal hammers (mounted in his machine) combined for the purpose of tapering and forming the points of the nails; which, being made to act alternately, resemble hand work, and are therefore not so apt to injure the fibrous texture of the iron, he imagines, as the rolling machinery is. He finishes the points by rollers.

Miles Berry, February 19, 1834, for machinery for forming metal into bolts, rivets, nails, and other articles; being a communication from a foreigner residing abroad. He employs in his machine holding chaps, heading dies, toggle joints, cams, &c., mechanisms apparently skilfully contrived, but too complex for admission under the article *nail* in this volume.

William Southwood Stocker, July, 1836. This is a machine apparently of American parentage, as it has the same set of features as the old American mechanisms of Perkins and Dyer, at the Britannia Nail-works, Birmingham, and all the other American machines since described, for pressing metal into the forms of nails, pins, screw-shafts, rivets, &c.; for example, it possesses pressers or hammers for squeezing the rods of metal, and forming the shanks, which are all worked by a rotatory action; cutters for separating the appropriate lengths, and dies for forming the heads by compression, also actuated by revolving cams or cranks.

Mr. Stocker intends, in fact, to effect the same sorts of operations by automatic mechanisms as are usually performed by the hands of a nail-maker with his hammer and anvil; viz., the shaping of a nail from a heated rod of iron, cutting it off at the proper length, and then compressing the end of the metal into the form of the head. His machine may be said to consist of two parts, connected in the same frame; the one for shaping the shank of the nail, the other for cutting it off and heading it. The frame consists of a strong table to bear the machinery. Two pairs of hammers, formed as levers, the one pair made to approach each other by horizontal movements, the other pair by vertical movements, are the implements by which a portion at the end of a redhot rod of iron is beaten or pressed into the wedge-like shape of the shaft of a nail. This having been done, and the rod being still hot, is withdrawn from the beaters, and placed in the other part of the machine, consisting of a pair of jaws like those of a vice, which pinch the shank of the nail and hold it fast. A cutter upon the side of a wheel now comes round, and, by acting as the moving chap of a pair of shears, cuts the nail off from the rod. The nail shank being still firmly held in the jaws of the vice, with a portion of its end projecting outwardly, the heading die is slidden laterally until it comes opposite to the end of the nail; the die is then projected forward with great force, for the purpose of what is termed upsetting the metal at the projecting end of the nail, and thereby blocking out the head.

A main shaft, driven by a band and rigger as usual, brings, as it revolves, a cam into operation upon a lever which carries a double inclined plane or wedge in its front or acting part. This wedge being by the rotatory cam projected forwards between the tails of one of the pairs of hammers, causes the faces of these hammers to approach each other, and to beat or press the redhot iron introduced between them, so as to flatten it upon two opposite sides. The rotatory cam passing round, the wedge lever is relieved, when springs instantly throw back the hammers; another cam and wedge-lever now brings the second pair of hammers to act upon the other two sides of the nail in a similar way. This is repeated several times, until the end of the redhot iron rod, gradually advanced by the hands of the workman, has assumed the desired form, that is, has received the bevel and point of the intended nail.

The rod is then withdrawn from between the hammers, and in its heated state is introduced between the jaws of the holders, for cutting off and finishing the nail. A bevel pinion upon the end of the main shaft, takes into and drives a wheel upon a transverse shaft, which carries a cam that works the lever of the holding jaws. The end of the rod being so held in the jaws or vice, a cutter at the side of a wheel upon the transverse shaft separates, as it revolves, the nail from the end of the rod, leaving the nail firmly held by the jaws. By means of a cam, the heading die is now slidden laterally opposite to the end of the nail in the holding jaws, and by another cam, upon the main shaft, the die is forced forward, which compresses the end of the nail, and spreads out the nail into the form of a head. As the main shaft continues to revolve, the cams pass away, and allow the spring to throw the jaws of the vice open, when the nails fall out; but to guard against the chance of a nail sticking in the jaws, a picker is provided, which pushes the nail out as soon as it is finished.

In order to produce round shafts, as for screw blanks, bolts, or rivets, the faces of the hammers, and the dies for heading, must be made with suitable concavities.

In 1835, 5,180, and in 1836, 5,580 tons of iron nails were exported from the United Kingdom.

NANKIN is a peculiarly colored cotton cloth, originally manufactured in the above named ancient capital of China, from a native cotton of a brown yellow hue. Nankin cloth has been long imitated in perfection by our own manufacturers; and is now exported in considerable quantities from England to Canton. The following is the process for dyeing calico a nankin color.

1. Take 300 pounds of cotton yarn in hanks, being the quantity which four workmen can dye in a day. The yarn for the warp may be about No. 27's, and that for the weft 23's or 24's.

2. For *aluming* that quantity, take 10 pounds of saturated alum, free from iron (see MORDANT); divide this into two portions; dissolve the first by itself in hot water, so as to form a solution of spec. grav. 1° Baumé. The second portion is to be reserved for the galling bath.

3. *Galling* is given with about 80 pounds of oak bark finely ground. This bark may serve for two quantities, if it be applied a little longer the second time.

4. Take 30 pounds of fresh slaked quicklime, and form with it a large bath of lime-water.

5. *Nitro-muriate of tin.* For the last bath, 10 or 12 pounds of solution of tin are used, which is prepared as follows:

Take 10 pounds of strong nitric acid, and dilute with pure water till its specific gravity be 26° B. Dissolve in it 4633 grains (10½ oz. avoird.) of sal ammoniac, and 3 oz. of nitre. Into this solvent, contained in a bottle set in cold water, introduce successively, in very small portions, 28 ounces of grain-tin granulated. This solution, when made, must be kept in a well stoppered bottle.

Three coppers are required, one round, about five feet in diameter, and 32 inches deep, for scouring the cotton; 2. two rectangular coppers tinned inside, each 5 feet long and 20 inches deep. Two boxes or cisterns of white wood are to be provided, the one for the lime-water bath, and the other for the solution of tin, each about 7 feet long, 32 inches wide, and 14 inches deep; they are set upon a platform 28 inches high. In the middle between these two chests, a plank is fixed, mounted with twenty-two pegs for wringing the hanks upon, as they are taken out of the bath.

6. *Aluming.* After the cotton yarn has been scoured with water, in the round copper, by being boiled in successive portions of 100 pounds, it must be winced in one of the square tinned coppers, containing two pounds of alum dissolved in 96 gallons of water, at a temperature of 165° F. It is to be then drained over the copper, exposed for some time upon the grass, rinsed in clear water, and wrung.

7. The *galling.* Having filled four-fifths of the second square copper with water, 40 pounds of ground oak bark are to be introduced, tied up in a bag of open canvass, and boiled for two hours. The bag being withdrawn, the cotton yarn is to be winced through the boiling tan bath for a quarter of an hour. While the yarn is set to drain above the bath, 28 ounces of alum are to be dissolved in it, and the yarn being once more winced through it for a quarter of an hour, is then taken out, drained, wrung, and exposed to the air. It has now acquired a deep but rather dull yellowish color, and is ready without washing for the next process. Bablah may be substituted for oak bark with advantage.

8. The *liming.* Into the cistern filled with fresh made lime-water, the hanks of cotton yarn, suspended upon a series of wooden rods, are to be dipped freely three times in rapid succession; then each hank is to be separately moved by hand through the lime bath, till the desired carmelite shade appear. A weak soda ley may be used instead of lime water.

9. The *brightening* is given by passing the above hanks, after squeezing, rinsing, and airing them, through a dilute bath of solution of tin. The color thus produced is said to resemble perfectly the nankin of China.

Another kind of nankin color is given by oxyde of iron, precipitated upon the fibre of the cloth, from a solution of the sulphate, by a solution of soda. See CALICO-PRINTING.

NAPLES YELLOW (*Jaune minéral*, Fr.; *Neapelgelb*, Germ.), is a fine yellow pigment, called *giallolino*, in Italy, where it has been long prepared by a secret process; for few of the recipes which have been published produce a good color. It is employed not only in oil painting, but also for porcelain and enamel. It has a fresh, brilliant, rich hue, but is apt to be very unequal in different samples.

The following prescription has been confidently recommended. Twelve parts of metallic antimony are to be calcined in a reverberatory furnace, along with eight parts of red lead, and four parts of oxyde of zinc. These mixed oxydes, being well rubbed together, are to be fused; and the fused mass is to be triturated and elutriated into a fine powder. Chromate of lead has in a great measure superseded Naples yellow.

NAPTHA, or ROCK-OIL (*Huile pétrole*, Fr., *Steinöl*, Germ.); the Seneca oil of North America is an ethereous or volatile oil, which is generated within the crust of the earth, and issues in many different localities. The colorless kind, called naptha, occurs at Baku, near the Caspian Sea, where the vapors which it exhales are kindled, and the flame is applied to domestic and other economical purposes. Wells are also dug in that neighborhood, in which the naptha is collected. Similar petroleum wells exist in the territory of the Birmans, at Yananghoung, upon the river Erawaddy, 80 hours' journey north-east of Pegu, where no less than 520 such springs issue from a *pale blue* clay, soaked with oil, which rests upon roofing slate. Under the slate is coal containing much pyrites. Each spring yields annually 173 casks of 950 pounds each. Petroleum is also found at Amiano in the dutchy of Parma, at Saint Zibio in the grand dutchy of Modena, at Neufchatel in Switzerland, at Clermont in France, upon some points of the banks of the Iser, at Gabian, a village near Bezières, at Tegernsee in Bavaria, at Val di Noto in Sicily, in Zante, Gallicia, Wallachia, Trinidad, Barbadoes, the United States, Rangoon, near Ava, &c. What is found in the market comes mostly from Trinidad. The city of Parma is lighted with naptha.

The Persian rock-oil is colorless, limpid, very fluid, of a penetrating odor, a hot taste, and a specific gravity of 0·753; it is said to boil at 160° F. The common petroleum has a reddish-yellow color, which appears blue by reflected light, is transparent, has a spec. grav. of 0·836, and contains, according to Unverdorben, several oils of different degrees of volatility, a little oleine and stearine, resin, with a brown indifferent substance held in solution. By repeated rectifications its density may be reduced to 0·758 at 60° F. Native naptha, of specific gravity 0·749, is said by some to boil at 201° F. The condensed vapor consists of 85·05 carbon, and 14·30 hydrogen.

The naptha procured by distilling the coal oil of the gas-works, is of specific gravity 0·857, boils at 316° F., and consists of, carbon 83·04, hydrogen 12·31, and oxygen 4·65, by my experiments.

Rock-oil is very inflammable; its vapor forms with oxygen gas a mixture which violently detonates, and produces water and carbonic acid gas. It does not unite with water, but it imparts a peculiar smell and taste to it; it combines in all proportions with strong alcohol, with ether and oils, both essential and unctuous; it dissolves sulphur, phosphorus, iodine, camphor, most of the resins, wax, fats, and softens caoutchouc into a glairy varnish. When adulterated with oil of turpentine, it becomes thick and reddish brown, on being agitated in contact with strong sulphuric acid. A very fine black pigment may be prepared from the soot of petroleum lamps.

NAPTHALINE is a peculiar white crystallizable substance, which may be extracted by distillation from coal tar. It has a pungent aromatic smell and taste, and a specific gravity of 1·048. It is a solid bicarburet of hydrogen, consisting, by my experiments, of 92·9 of carbon, and 7·1 of hydrogen. It has not been applied to any use.

NATRON is the name of the native sesquicarbonate of soda, which occurs in Egypt, in the west of the Delta; also in the neighborhood of Fessan, in the province of Sukena in Northern Africa, where it exists under the name of *Trona*, crystallized along with sulphate of soda; near Symrna, in Tartary, Siberia, Hungary, Hindostan, and Mexico. In the last country, there are several natron lakes, a little to the north of Zucatecas, as well as in many other provinces. In Columbia, 48 miles from Merida, native mineral natron is dug up from the bottom of lakes in large quantities, under the name of *Urao*.

According to Laugier, the Egyptian natron consists of carbonate of soda 22·44, sulphate of soda 18·35, muriate of soda 38·64, water 14·0, insoluble matter 6·0. Trona is composed of carbonate of soda 65·75, sulphate of soda 7·65, muriate of soda 2·63, water 24, insoluble matter 1. The sesquicarbonate may be artificially prepared by boiling for a short time a solution of the bicarbonate.

NEALING. See ANNEALING.

NEB-NEB is the East Indian name of Bablah.

NEEDLE MANUFACTURE. When we consider the simplicity, smallness, and moderate price of a needle, we would be naturally led to suppose that this little instrument requires neither much labor nor complicated manipulations in its construction; but when we learn that every sewing needle, however inconsiderable its size, passes through the hands of 120 different operatives, before it is ready for sale, we cannot fail to be surprised.

The best steel, reduced by a wire-drawing machine to the suitable diameter, is the material of which needles are formed. It is brought in bundles to the needle factory, and carefully examined. For this purpose, the ends of a few wires in each bundle are cut off, ignited, and hardened by plunging them into cold water. They are now snapped between the fingers, in order to judge of their quality; the bundles belonging to the most brittle wires are set aside, to be employed in making a peculiar kind of needles.

After the quality of the steel wire has been properly ascertained, it is calibred by means of a gauge, to see if it be equally thick and round throughout, for which purpose merely some of the coils of the bundle of wires are tried. Those that are too thick are returned to the wire-drawer, or set apart for another size of needles.

The first operation, properly speaking, of the needle factory, is unwinding the bundles of wires. With this view the operative places the coil upon a somewhat conical reel, *fig.* 750, whereon he may fix it at a height proportioned to its diameter. The wire is wound off upon a wheel B, formed of eight equal arms, placed at equal distances round a nave, which is supported by a polished round axle of iron, made fast to a strong upright C, fixed to the floor of the workshop. Each of the arms is 54 inches long; and one of them, D, consists of two parts; of an upper part, which bears the cross bar E, to which the wire is applied; and of an under part, connected with the nave. The part E slides in a slot in the fixed part F, and is made fast to it by a peg at a proper height for placing the ends of all the spokes in the circumference of a circle. This arrangement is necessary, to permit the wire to be readily taken off the reel, after being wound tight round its eight branches. The peg is then removed, the branch pushed down, and the coil of wire released. *Fig.* 751 shows the wheel in profile. It is driven by the winch-handle G.

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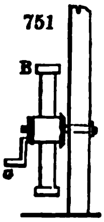

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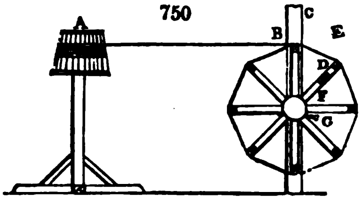

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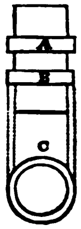

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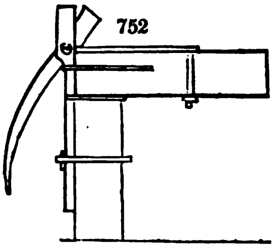

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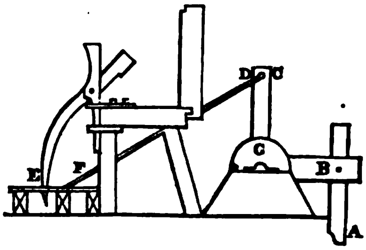


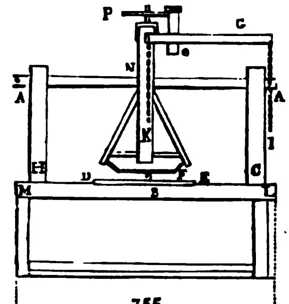
The new made coil is cut in two points diametrically opposite, either by hand shears, of which one of the branches is fixed in a block by a bolt and a nut, as shown in *fig.* 752, or by means of the mechanical shears, represented in *fig.* 753. The crank A is moved by a hydraulic wheel, or steam power, and rises and falls alternately. The extremity of this crank enters into a mortise cut in the arm B of a bent lever B G C, and is made fast to it by a bolt. An iron rod D F, hinged at one of its extremities to the end of the arm C, and at the other to the tail of the shears or chisel E, forces it to open and shut alternately. The operative placed upon the floor under F presents the coil to the action of the shears, which cut it into two bundles, composed each of 90 or 100 wires, upwards of 8 feet long. The chisel strikes 21 blows in the minute.

These bundles are afterwards cut with the same shears into the desired needle lengths, these being regulated by the diameter. For this purpose the wires are put into a semi-cylinder of the proper length, with their ends at the bottom of it, and are all cut across by this gauge. The wires, thus cut, are deposited into a box placed alongside of the workman.

Two successive incisions are required to cut 100 wires, the third is lost; hence the shears, striking 21 blows in a minute, cut in 10 hours fully 400,000 ends of steel wire, which produce more than 800,000 needles. The wires thus cut are more or less bent, and require to be straightened. This operation is executed with great promptitude, by means of an appropriate instrument. In two strong iron rings A B, *fig.* 754, of which one is shown in front view at C, 5000 or 6000 wires, closely packed together, are put; and the bundle is placed upon a flat smooth bench L M, *fig.* 757, covered with a cast-iron plate D E, in which there are two grooves of sufficient depth for receiving the two ring bundles of wire, or two openings like the rule F, *fig.* 757, upon which is placed the open iron rule F, shown in front in *fig.* 756 upon a greater scale. The two rings must be carefully set in the intervals of the rule. By making this rule come and go five or six times with such pressure upon the bundles of wires as causes it to turn upon its axis, all the wires are straightened almost instantaneously.

The construction of the machine, represented in *fig.* 757, may require explanation. It consists of a frame in the form of a table, of which L M is the top; the cast-iron plate D E is inserted solidly into it. Above the table, seen in *fig.* 755 in plan, there are two uprights C H, to support the cross bar A A, which is held in forks cut out in the top of each of the two uprights. This cross bar A A, enters tightly into a mortise cut in the swing piece N, at the point N, where it is fixed by a strong pin, so that the horizontal traverse communicated to the cross bar A A affects at the same time the swing piece N. At the bottom of this piece is fixed, as shown in the figure, the open rule F, seen upon a greater scale in *fig.* 756.

757



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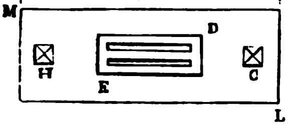

When the workman wishes to introduce the bundle B, he raises, by means of two chains I K, *fig.* 757, and the lever G O, the swing piece and the cross bar. For this purpose he draws down the chain I; and when he has placed the bundle properly, so that the two rings enter into the groove E D, *fig.* 755, he allows the swing piece to fall back, so that the same rings enter the open clefts of the rule F; he then seizes one of the projecting arms of the cross bar A, alternately pulling and pushing it in the horizontal direction, whereby he effects, as already stated, the straightening of the wires.

The wires are now taken to the pointing-tools, which usually consist of about 30 grindstones arranged in two rows, driven by a water-wheel. Each stone is about 18 inches in diameter, and 4 inches thick. As they revolve with great velocity, and are liable to fly in pieces, they are partially incased by iron plates, having a proper slit in them to admit of the application of the wires. The workman seated in front of the grindstone, seizes 50 or 60 wires between the thumb and forefinger of his right hand, and directs one end of the bundle to the stone. By means of a bit of stout leather called a thumb-piece, of which A, *fig.* 758, represents the profile, and B the plan, the workman presses the wires, and turns them about with his forefinger, giving them such a rotatory motion as to make their points conical. This operation, which is called *roughing down*, is dry grinding; because, if water were made use of, the points of the needles would be rapidly rusted. It has been observed long ago, that the silicious and steel dust thrown off by the stones, was injurious to the eyes and lungs of the grinders; and many methods have been proposed for preventing its bad effects. The machine invented for this purpose by Mr. Prior, for which the Society of Arts voted a premium, deserves to be generally known.

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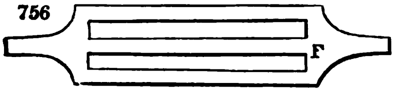

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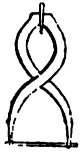

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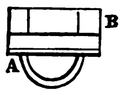

A A, *fig.* 759, is the fly-wheel of an ordinary lathe, round which the endless cord B B passes, and embraces the pulley C, mounted upon the axle of the grindstone D. The fly-wheel is supported by a strong frame E E, and may be turned by a winch-handle, as usual, or by mechanical power. In the needle factories, the pointing-shops are in general very large, and contain several grindstones running on the same long horizontal shaft, placed near the floor of the apartment, and driven by water or steam power. One of the extremities of the shaft of the wheel A has a kneed or bent winch F, which by means of an intermediate crank G G, sets in action a double bellows H I, with a continuous blast, consisting of the air feeder H below, and the air regulator I above. The first is composed of two flaps, one of them, *a a*, being fast and attached to the floor, and the other, *e e*, moving with a hinge-joint; both being joined by strong leather nailed to their edges. This flap has a tail *g*, of which the end is forked to receive the end of the crank G. Both flaps are perforated with openings furnished with valves for the admission of the air, which is thence driven into a horizontal pipe K, placed beneath the floor of the workshop, and may be afterwards directed in an uninterrupted blast upon the grindstone, by means of the tin tubes N O O, which embrace it, and have longitudinal slits in them. A brass socket is supposed to be fixed upon the ground; it communicates with the pipe K, by means of a small copper tube, into which one of the extremities of the pipe N is fitted; the other is supported by the point of a screw Q, and moves round it as a pivot, so as to allow the two upright branches O O, to be placed at the same distance from the grindstone. These branches are soldered to the horizontal pipe N, and connected at their top by the tube P.

The wind which escapes through the slits of these pipes, blows upon the grindstone, and carries off its dust into a conduit R, *fig.* 759, which may be extended to S, beyond the wall of the building, or bent at right angles, as at T, to receive the conduits of the other grindstones of the factory.

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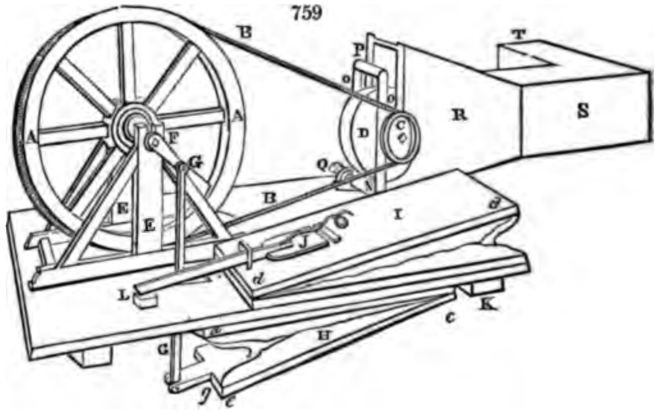

A safety valve J, placed in an orifice formed in the regulator flap I, is kept shut by a spiral spring of strong iron wire. It opens to allow the superfluous air to escape, when, by the rising of the bellows, the tail L presses upon a small piece of wood, and thereby prevents their being injured.

The wires thus pointed at both ends are transferred to the first workshop, and cut in two, to form two needles, so that all of one quality may be of equal length. For each sort a small instrument, *fig*. 760, is employed, being a copper plate nearly square, having a turned up edge only upon two of its sides; the one of which is intended to receive all the points, and the other to resist the pressure of the shears. In this small tool a certain number of wires are put with their points in contact with the border, and they are cut together flush with the plate by means of the shears, *fig*. 752, which are moved by the knee of the workman. The remainder of the wires are then laid upon the same copper or brass tool, and are cut also even; there being a trifling waste in this operation. The pieces of wire out of which two needles are formed, are always left a little too long, as the pointer can never hit exact uniformity in his work.

These pointed wires are laid parallel to each other in little wooden boxes, and transferred to the head-flattener. This workman, seated at a table with a block of steel before him, about 3 inches cube, seizes in his left hand 20 or 25 needles, between his finger and thumb, spreading them out like a fan, with the points under the thumb, and the heads projecting; he lays these heads upon the steel block, and with a small flat-faced hammer strikes successive blows upon all the heads, so as to flatten each in an instant. He then arranges them in a box with the points turned the same way.

The flatted heads have become hardened by the blow of the hammer; when annealed by heating and slow cooling, they are handed to the *piercer*. This is commonly a child, who laying the head upon a block of steel, and applying the point of a small punch to it, pierces the eye with a smart tap of a hammer, applied first upon the one side, and then exactly opposite upon the other.

Another child trims the eyes, which he does by laying the needle upon a lump of lead, and driving a proper punch through its eye; then laying it sidewise upon a flat piece of steel, with the punch sticking in it, he gives it a tap on each side with his hammer, and causes the eye to take the shape of the punch. The operation of piercing and trimming the eyes, is performed by clever children with astonishing rapidity; who become so dexterous as to pierce with their punch a human hair, and thread it with another, for the amusement of visiters.

The next operative makes the groove at the eye, and rounds the head. He fixes the needle in pincers, *fig*. 761, so that the eye corresponds to their flat side; he then rests the head of the needle in an angular groove, cut in a piece of hard wood fixed in a vice, with the eye in an upright position. He now forms the groove with a single stroke of a small file, dexterously applied, first to the one side of the needle, and then to the other. He next rounds and smooths the head with a small flat file. Having finished, he opens the pincers, throws the needle upon the bench, and puts another in its place. A still more expeditious method of making the grooves and finishing the heads has been long used in most English factories. A small ram is so mounted as to be made to rise and fall by a pedal lever, so that the child works the tool with his foot; in the same way as the heads of pins are fixed. A small die of tempered steel bears the form of the one channel or groove, another similar die, that of the other, both being in relief; these being worked by the lever pedal, finish the grooving of the eye at a single blow, by striking against each other, with the head of the needle between them.

The whole of the needles thus prepared are thrown pell-mell into a sort of drawer or box, in which they are, by a few dexterous jerks of the workman's hand, made to arrange themselves parallel to each other.

The needles are now ready for the tempering; for which purpose they are weighed out in quantities of about 30 pounds, which contain from 250,000 to 500,000 needles, and are carried in boxes to the *temperer*. He arranges these upon sheet-iron plates, about 10 inches long, and 5 inches broad, having borders only upon the two longer sides. These plates are heated in a proper furnace to bright redness for the larger needles, and to a less intense degree for the smaller; they are taken out, and inverted smartly over a cistern of water, so that all the needles may be immersed at the same moment, yet distinct from one another. The water being run off from the cistern, the needles are removed, and arranged by agitation in a box, as above described. Instead of heating the needles in a furnace, some manufacturers heat them by means of a bath of melted lead in a state of ignition.

After being suddenly plunged in the cold water, they are very hard and excessively brittle. The following mode of tempering them is practised at Neustadt. The needles are thrown into a sort of frying-pan along with a quantity of grease. The pan being placed on the fire, the fatty matter soon inflames, and is allowed to burn out; the needles are now found to be sufficiently well tempered. They must, however, be re-adjusted upon the steel anvil, because many of them get twisted in the hardening and tempering.

Polishing is the longest and not the least expensive process in the needle manufacture. This is done upon bundles containing 500,000 needles; and the same machine, under the guidance of one man, polishes from 20 to 30 bundles at a time; either by water or steam power. The needles are rolled up in canvass along with some quartzose sand interstratified between their layers, and the mixture is besmeared with rape-seed oil. *Fig.* 762 represents one of the rolls or packets of needles 12 inches long, strongly bound with cords. These packets are exposed to the to-and-fro pressure of wooden tables, by which they are rolled about, with the effect of causing every needle in the bundle to rub against its fellow, and against the silicious matter, or emery, enclosed in the bag. *Fig.* 763 represents an improved table for polishing the needles by attrition-bags. The lower table M M is moveable, whereas in the old constructions it was fixed; the table C has merely a vertical motion, of pressure upon the bundles, whereas formerly it had both a vertical and horizontal motion. Several bundles may obviously be polished at once in the present machine. The table M M may be of any length that is required, and from 24 to 27 inches broad; resting upon the wooden rollers B, B, B, placed at suitable distances, it receives a horizontal motion, either by hand or other convenient power; the packets of needles A, A, A, are laid upon it, and over them the tables C, C, C, which are lifted by means of the chains K, K, K, and the levers L, L, L, in order to allow the needles to be introduced or removed. The see-saw motion forces the *rouleaux* to turn upon their own axes, and thereby creates such attrition among their contents as to polish them. The workman has merely to distribute these rolls

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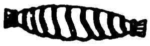

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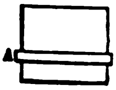

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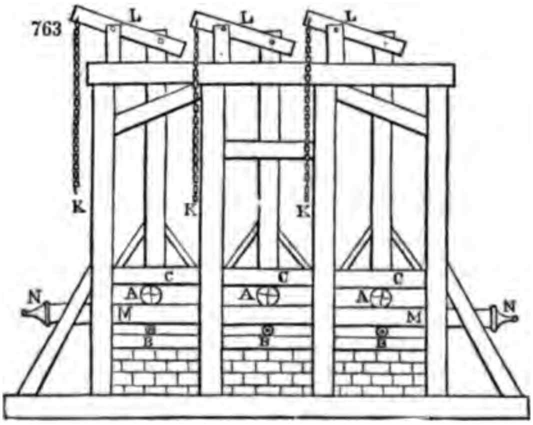


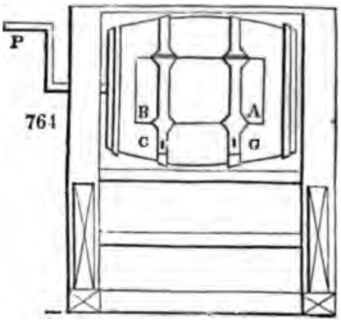
upon the table M, in a direction perpendicular to that in which the table moves; and whenever one of them gets displaced, he sets it right, lifting by the help of the chain the loaded table. The table makes about 20 horizontal double vibrations in the minute; whereby each bundle, running over 24 inches each time, passes through 40 feet per minute, or 800 yards in the hour.

Scouring by the cask. After being worked during 18 or 20 hours under the tables, the needles are taken out of the packets, and put into wooden bowls, where they are mixed with sawdust to absorb the black grease upon their surfaces. They are next introduced into a cask, *fig.* 764, and a workman seizing the winch P, turns it round a little; he now puts in some more sawdust at the door, A, B, which is then shut by the clasps G G, and continues the rotation till the needles be quite clean and clear in their eyes; which he ascertains by taking out a sample of them from time to time.

Winnowing is the next process, by means of a mechanical ventilator similar to that by which corn is winnowed. The sawdust is blown away, and the grinding powder is separated from the needles, which remain apart clean and bright.

The needles are in the next place arranged in order, by being shaken, as above described, in a small somewhat concave iron tray. After being thus laid parallel to each other, they are shaken up against the end of the tray, and accumulated in a nearly upright position, so that they can be seized in a heap and removed in a body upon a pallet knife, with the help of the forefinger.

The preceding five operations, of making up the *rouleaux*, rolling them under the tables, scouring the needles in the cask, winnowing, and arranging them, are repeated ten times in succession, in manufacturing the best articles; the only variation being in the first process. Originally the bundles of needles are formed with alternate layers of silicious schistus and needles; but after the seventh time, bran freed from flour by sifting is substituted for the schistus. The subsequent four processes are, however, repeated as described. It has been found in England, that emery powder mixed with quartz and mica or pounded granite, is preferable to everything else for polishing needles at first by attrition in the bags; at the second and following operations, emery mixed with olive oil is used, up to the eighth and ninth, for which putty or oxyde of tin with oil is substituted for the emery; at the tenth the putty is used with very little oil; and lastly bran is employed to give a finish. In this mode of operating, the needles are *scoured* in the copper cask shown in elevation in *fig.* 765, and in section in *fig.* 766. The inner surface of this cask is studded with points to increase the friction among the needles; and a quantity of hot soap suds is repeatedly introduced to wash them clean. The cask must be slowly turned upon its axis, for fear of injuring the mass of needles which it contains. They are finally dried in the wooden cask by attrition with sawdust; then wiped individually with a linen rag or soft leather; when the damaged ones are thrown aside.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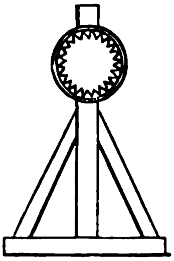

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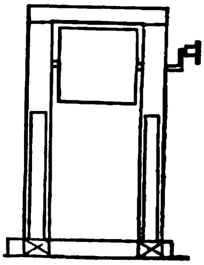


Sorting of the needles. This operation is performed in a dry upper chamber, kept free from damp by proper stoves. Here all the points are first laid the same way; and the needles are then picked out from each other in the order of their polish. The sorting is effected with surprising facility. The workman places 2000 or 3000 needles in an iron ring, *fig.* 767, two inches in diameter, and sets all their heads in one plane; then on looking carefully at their points, he easily recognises the broken ones; and by means of a small hook fixed in a wooden handle, *fig.* 768, he lays hold of the broken needle, and turns it out. These defective needles pass into the hands of another workman, who points them anew upon a grindstone, and they form articles of inferior value. The needles which have got bent in the polishing must now be straightened. The whole are finally arranged exactly according to their lengths by the tact of the finger and thumb of the sorter.

The needles are divided into quantities for packing in blue papers, by putting into a small balance the equivalent weight of 100 needles, and so measuring them out without the trouble of counting them individually.

The *bluer* receives these packets, and taking 25 of their needles at a time between the forefinger and thumb, he presses their points against a very small hone-stone of compact micaceous schist, mounted in a little lathe, as shown in *fig.* 769, he turns them briskly round, giving the points a bluish cast, while he polishes and improves them. This partial polish is in the direction of the axis; that of the rest of the needle is transverse, which distinguishes the boundaries of the two. The little hone-stone is not cylindrical, but quadrangular, so that it strikes successive blows with its corners upon the needles as it revolves, producing the effect of filing lengthwise. Whenever these angles seem to be blunted, they are set again by the *bluer.*

It is easy to distinguish good English needles from spurious imitations; because the former have their axis coincident with their points, which is readily observed by turning them round between the finger and thumb.

The construction of a needle requires, as already stated, about 120 operations; but they are rapidly and uninterruptedly successive. A child can *trim* the eyes of 4000 needles per hour.

When we survey a manufacture of this kind, we cannot fail to observe, that the diversity of operations which the needles undergo bears the impress of great mechanical refinement. In the arts, to divide labor, is to abridge it; to multiply operations, is to simplify them; and to attach an operative exclusively to one process, is to render him much more economical and productive.

NEROLI is the name given by perfumers to the essential oil of orange flowers. It is procured by distillation with water, in the same way as the other volatile oils. Since in distilling water from neroli, an aroma is obtained different from that of the orange-flower, it has been concluded that the distilled water of orange-flowers owes its scent to some principle different from an essential oil.

NET (*Filet, reseau,* Fr.; *Netz,* Germ.) is a textile fabric of knotted meshes, for catching fish, and other purposes. Each mesh should be so secured as to be incapable of enlargement or diminution. The French government offered in 1802 a prize of 10,000 francs to the person who should invent a machine for making nets upon automatic principles, and adjudged it to M. Buron, who presented his mechanical invention to the *Conservatoire des Arts et Métiers.* It does not appear, however, that this machine has accomplished the object in view; for no establishment was ever mounted to carry it into execution. Nets are usually made by the fishermen and their families during periods of leisure. The formation of a mesh is too simple a matter to require description in this Dictionary.

NEUTRALIZATION is the state produced when acid and alkaline matters are combined in such proportions that neither predominates, as evinced by the color of tincture of litmus and cabbage remaining unaffected by the combination.

NICARAGUA WOOD is the wood of the *Cæsalpinia echinata,* a tree which grows in Nicaraca. It is used with solution of tin as a mordant to dye a bright but fugitive red. It is an inferior sort of Brazil wood.

NICKEL is a metal rather sparingly found, and in few localities; being usually associated with cobalt. Native nickel occurs at Westerwald in the Erzegebirge, in Bohemia, combined with arsenic, under the significant name of *Kupfernickel;* with cobalt, iron, and copper, as *Arsenic-nickel,* in the Harz; at Riechelsdorf in Hessia; as an oxyde, in *Nickelschwärtze;* as a sulphuret of nickel in *Haarkies;* as a sulphuret and arseniate of nickel in *Nickelglanz;* and with sulphur and antimony in *Nickelspiess glanzerz* at Siegen. Nickel is always present in meteoric stones. Kupfernickel occurs in numerous external shapes; as reniform, globular, botroidal, arborescent, massive, and disseminated; fracture, coarse or fine grained, with metallic lustre; color, copper red, occasionally brown and gray; in silver and cobalt veins, in gneiss, sienite, mica-slate, kupfer-schiefer, accompanied by speisse cobalt, native silver, quartz, &c. It is found in Westphalia near Olpe, in Hessia at Riechelsdorf, and Biber, in Baden; in the Saxon Erzegebirge near Schneeberg, and Freiberg; in Bohemia, at Joachimsthal; in Thuringia, at Saalfeld; in Steyermark near Schladming; in Hungary, France, and England.

Since the manufacture of German silver, or *Argentane,* became an object of commercial importance, the extraction of nickel has been undertaken upon a considerable scale. The cobalt ores are its most fruitful sources, and they are now treated by the method of Wöhler, to effect the separation of the two metals. The arsenic is expelled by roasting the powdered *speise,* first by itself, next with the addition of charcoal powder, till the garlic smell be no longer perceived. The residuum is to be mixed with three parts of sulphur and one of potash, melted in a crucible with a gentle heat, and the product being edulcorated with water, leaves a powder of metallic lustre, which is a sulphuret of nickel free from arsenic; while the arsenic associated with the sulphur, and combined with the resulting sulphuret of potassium, remains dissolved. Should any arsenic still be found in the sulphuret, as may happen if the first roasting heat was too great, the above process must be repeated. The sulphuret must be finally washed, dissolved in concentrated sulphuric acid, with the addition of a little nitric, the metal must be precipitated by a carbonated alkali, and the carbonate reduced with charcoal.

In operating upon kupfernickel, or speise, in which nickel predominates, after the arsenic, iron, and copper have been separated, ammonia is to be digested upon the mixed oxydes of cobalt and nickel, which will dissolve them into a blue liquor. This being diluted with distilled water deprived of its air by boiling, is to be decomposed by caustic potash, till the blue color disappears, when the whole is to be put into a bottle tightly stoppered, and set aside to settle. The green precipitate of oxyde of nickel, which slowly forms, being freed by decantation from the supernatant red solution of oxyde of cobalt, is to be edulcorated and reduced to the metallic state in a crucible containing crown glass. Pure nickel in the form of a metallic powder is readily obtained by exposing its oxalate to modern ignition.

The reduction of the oxyde of nickel with charcoal requires the heat of a powerful air furnace or smith's forge.

Nickel possesses a fine silver white color and lustre; it is hard, but malleable, both hot and cold; may be drawn into wire $\frac{1}{50}$ of an inch, and rolled into plates $\frac{1}{500}$ of an inch thick. A small quantity of arsenic destroys its ductility. When fused it has a specific gravity of 8·279, and when hammered, of 8·66 or 8·82; it is susceptible of magnetism, in a somewhat inferior degree to iron, but superior to cobalt. Mariners' compasses may be made of it. Its melting point is nearly as high as that of manganese. It is not oxydized by contact of air, but may be burned in oxygen gas.

There is one oxyde and two suroxydes of nickel. The oxyde is of an ash-gray color, and is obtained by precipitation with an alkali from the solution of the muriate or nitrate. The niccolous suroxyde of Berzelius is black, and may be procured by exposing the nitrate to a heat under redness. The niccolic suroxyde has a dirty pale green color; but its identity is doubtful.

NICOTIANINE is the name of an oil recently extracted from the leaves of tobacco, which possesses the smell of tobacco smoke.

NICOTINE is a peculiar principle, obtainable from the leaves and seeds of tobacco (*nicotiana tabacum*), by infusing them in acidulous water, evaporating the infusion to a certain point, adding lime to it, distilling and treating the product which comes over with ether. It is colorless, has an acrimonious taste, a pungent smell, remains liquid at 20° F., mixes in all proportions with water, but is in a great measure separable from it by ether, which dissolves it abundantly. It combines with acids, and forms salts acrid and pungent like itself; the phosphate, oxalate, and tartrate being crystallizable. Nicotine causes the pupils to contract. A single drop of it is sufficient to kill a dog.

NITRATE OF AMMONIA is prepared by neutralizing nitric acid with carbonate of ammonia, and crystallizing the solution.

NITRATE OF LEAD (*Nitrate de plomb*, Fr.; *Salpetersaures bleioxyd*, Germ.) is made by saturating somewhat dilute nitric acid with oxyde of lead (litharge), evaporating the neutral solution till a pellicle appears, and then exposing it in a hot chamber till it be converted into crystals, which are sometimes transparent, but generally opaque white octahedrons. Their spec. grav. is 4·068; they have a cooling, sweetish, pungent taste. They dissolve in 7 parts of cold, and in much less boiling water; they fuse at a moderate elevation of temperature, emit oxygen gas, and pass into oxyde of lead. Their constituents are 67·3 oxyde, and 32·7 acid. Nitrate of lead is much employed in the chrome yellow style of CALICO-PRINTING; which see.

There are three other compounds of nitric acid and lead oxyde; viz., the bi-basic the tri-basic, and the se-basic; which contain respectively 2, 3, and 6 atoms of base to 1 of acid.

NITRATE OF POTASH, *Nitre*, *Saltpetre*. (*Nitrate de potasse*, Fr.; *Salpetersaures kali*, Germ.) This salt occurs native as an efflorescence upon limestones, sandstones, marls, chalk, and calctuff; it forms a saline crust in caverns, as also upon the surface of the ground in certain places, especially where animal matters have been decomposed. Such caverns exist in Germany near Homburg (Burkardush); in Apulia upon the Adriatic sea (Pulo di Mofetta); in France; in the East Indies; in Ceylon, where 22 nitriferous caverns are mentioned; in North America, at Crooked river, Tennessee, Kentucky, and upon the Missouri; in Brazil, Teneriffe, and Africa. Nitre occurs as an efflorescence upon the ground in Arragon, Hungary, Podolia, Sicily, Egypt, Persia, Bengal, China, Arabia, North America, and South America. Several plants contain saltpetre; particularly borage, dill, tobacco, sunflowers, stalks of maize, beet-root, bugloss, parietaria, &c. It has not hitherto been found in animal substances.

The question has been frequently put; how is nitre annually reproduced upon the surface of limestones, and the ground, after it has been removed by washing? It has aid, in reply, that as secondary limestones contain remains of animal matters, ygen of the atmosphere, absorbed in virtue of the porous structure, will com- ith their azote to form nitric acid; whence nitrate of lime will result. Where is present in the ground, a nitrate of that base will be next formed. The generation e is in all cases limited to a very small distance from the surface of porous stones; ther, indeed, than where atmospherical air and moisture can penetrate; and none produced upon the surface of compact stones, such as marble and quartz, or of ceous minerals. Dr. John Davy and M. Longchamp have advanced an opinion, e presence of azotized matter is not necessary for the generation of nitric acid or salts, but that the oxygen and azote of the atmosphere, when condensed by capil- will combine in such proportions as to form nitric acid, through the agency of re and of neutralizing bases, such as lime, magnesia, potash, or soda. They conceive spongy platina serves to combine oxygen and hydrogen into water, or the vapor hol and oxygen into acetic acid, and as the peroxyde as well as the hydrate of iron, gillaceous minerals, serve to generate ammonia from the oxygen of the air and the en of water; in like manner, porous limestones, through the agency of water, e upon the constituents of the atmosphere to produce nitric acid, without the pres- f animal matter. This opinion may certainly be maintained; for in India, Spain, veral other countries, at a distance from all habitations, immense quantities of salt- re reproduced in soils which have been washed the year before. But, on the and, it is known that the production of this salt may be greatly facilitated and in- d by the admixture of animal offals with calcareous earths.

spontaneous generation of nitre in Spain, Egypt, and especially in India, is suffi- o supply the wants of the whole world. There this salt is observed to form upon rface of the ground in silky tufts, or even in slender prismatic crystals, particu- uring the continuance of the hot weather that succeeds copious rains. These saline scences, after being collected by rude besoms of broom, are lixiviated, allowed to evaporated, and crystallized. In France, Germany, Sweden, Hungary, &c., vast ties of nitrous salts are obtained by artificial arrangements called *nitriaries*, or eds. Very little nitrate of potash, indeed, is obtained in the first place; but the s of lime and magnesia, which being deliquescent, remain in the nitrous earths in -liquid state. The operation of converting these salts into good nitre is often suf- ly complex, in consequence of the presence of several muriates, which are difficult inate.

following instructions have been given by the consulting committee of *poudres et es* in France, for the construction of their *nitrières artificielles*. The permeability materials to the atmospherical air, being found to be as indispensable as is the ce of a base to fix the nitric acid at the instant of its formation, the first measure elect a light friable earth, containing as much carbonate of lime or old mortar- h as possible; and to interstratify it with beds of dung, five or six inches thick, onsiderable heap be raised in the shape of a truncated pyramid, which should be under an open shed, and kept moist by watering it from time to time. When ole appears to be decomposed into a kind of mould, it is to be spread under sheds ers of from two to three feet thick; which are to be watered occasionally with and the drainings of dunghills, taking care not to soak them too much, lest they be rendered impermeable to the air, though they should be always damp enough r the absorption and mutual action of the atmospherical gases. Moist garden affords an example of the physical condition most favorable to nitre-beds. The st should be turned over, and well mixed with the spade once at least in every ht, and the sides of the shed should be partially closed; for although air be essen- ind is injurious, by carrying off the acid vapors, instead of allowing them to rest ent upon, and combine with, the bases. The chemical reaction is slow and sive, and can be made effective only by keeping the agents and materials in a f quiescence. The whole process lasts two years; but since organic matters yield in the lixiviation several soluble substances detrimental to the extraction of re, they must not be added during the operations of the latter six months; nor ny thing except clear water be used for watering during this period; at the end ch the whole organic ingredients of the beds will be totally decomposed. Where is not sufficiently abundant for the above stratifications, a nitre-bed should be in a stable with friable earth, covered with a layer of litter; after four months er is to be lifted off, the earth is to be turned over, then another layer of fresh 8 or 9 inches thick, is to be placed over it, and a layer of the old and fresh litter ll. At the end of other four months, this operation is to be repeated; and in the of a year the whole is ready to be transferred into the regular nitre-beds under a s above described. Such are the laborious and disagreeable processes practised peasants of Sweden, each of whom is bound by law to have a nitre-bed, and to a certain quantity of nitre to the state every year. His *nitriary* commonly consists of a small hut built of boards, with a bottom of rammed clay, covered by a wooden floor, upon which is spread a mixture of ordinary earth with calcareous sand or marl, and lixiviated wood-ashes. This mixture is watered with stable urine, and its surface is turned over once a week in summer, and once a fortnight in winter. In some countries, walls 2 or 3 feet thick, and 6 or 7 high, are raised with the nitrifying compost, interspersed with weeds and branches of trees, in order at once to bind them together, and to favor the circulation of air. These walls are thatched with straw; they are placed with one of their faces in the direction of the rains; and must be moistened with water not rich in animal matter. One side of the walls is upright and smooth; while the other is sloped or terraced, to favor the admission of humidity into their interior. The nitre eventually forms a copious efflorescence upon the smooth side, whence it may be easily scraped off.

M. Longchamp, convinced that organic matters are a useless expense, and not in the least essential to nitrification, proposes to establish nitre-beds where fuel and labor are cheapest, as amidst forests, choosing as dry and low a piece of ground as possible, laying them out upon a square space of about 1000 feet in each side, in the middle of which the graduation-house may be built, and alongside of it sheds for the evaporation furnaces and pans. Upon each of the four sides the *nitrifying* sheds are to be erected, 130 feet long by 30 feet wide, where the lixiviation would be carried on, and whence the water would be conducted in gutters to the graduation-house. The sheds are to be closed at the sides by walls of *pisé*, and covered with thatch. No substance is so favorable to nitrification as the natural stony concretion known under the name of lime-tuf. In Touraine, where it is used as a building stone, the saltpetre makers re-establish the foundations of old houses at their own expense, provided they are allowed to carry off the old tuf, which owes its nitrifying properties not only to its chemical nature, but to its texture, which being of a homogeneous porosity, permits elastic fluids and vapors to pass through it freely in all directions. With the rough blocks of such tuf, walls about 20 inches thick, and moderately high, are to be raised, upon the principles above prescribed; in the absence of tuf, porous walls may be raised with a mixture of arable soil, sand, and mortar-rubbish, chalk or rich marl. The walls ought to be kept moist.

In France, the greater part of the indigenous saltpetre is obtained by lixiviating the mortar-rubbish of old buildings, especially of those upon the ground-floor, and in sunk cellars; which are by law reserved for this purpose. The first object of the manufacturer is then to ascertain the richness of his materials in nitrous salts, to see if they be worth the trouble of working; and this point he commonly determines merely by their saline, bitter, and pungent taste, though he might readily have recourse to the far surer criteria of lixiviation and evaporation. He next pounds them coarsely, and puts them into large casks open at top, and covered with straw at bottom; which are placed in three successive levels. Water is poured into the casks till they are full, and after 12 hours' digestion it is run off, loaded with the salts, by a spigot near the bottom. A fresh quantity of water is then added, and drawn off after an interval of four hours; even a third and fourth lixiviation are had recourse to; but these weak liquors are reserved for lixiviating fresh rubbish. The contents of the casks upon the second and third lower levels are lixiviated with the liquors of the upper cask, till the leys indicate from 12 to 14 degrees of Baumé's hydrometer. They are now fit for evaporating to a greater density, and of then receiving the dose of wood-ashes requisite to convert the materials of lime and magnesia into nitrate of potash, with the precipitation of the carbonates of magnesia and lime. The solution of nitre is evaporated in a copper pan, and as it boils, the scum which rises to the surface must be diligently skimmed off into a cistern alongside. Muriate of soda being hardly more soluble in boiling than in cold water, separates during the concentration of the nitre, and is progressively removed with cullender-shaped ladles. The fire is withdrawn whenever the liquor has acquired the density of 80° B.; it is allowed to settle for a little while, and is then drawn off, by a lead syphon adjusted some way above the bottom, into iron vessels, to cool and crystallize. The crystals thus obtained are set to drain, then re-dissolved and re-crystallized. The further purification of nitre, is fully described under the article GUNPOWDER.

The annual production of saltpetre in France, by the above-described processes, during the wars of the Revolution, amounted to 2000 tons (2 millions of kilogrammes) of an article fit for the manufacture of gunpowder; of which seven twentieths were furnished by the saltpetre works of Paris alone. Considerably upwards of six times that quantity of common and cubic nitre were imported into the United Kingdom, for home consumption, during the year ending January 5, 1838.

Nitrate of potash crystallizes in six-sided prisms, with four narrow and two broad faces: the last being terminated by a dihedral summit, or two-sided acumination; they are striated lengthwise, and have fissures in their long axis, which are apt to contain mother water. The spec. gravity of nitre, varies from 1·93 to 2·00. It possesses oling, bitterish-pungent taste, is void of smell, permanent in the air when pure, at a heat of about 662, into an oily-looking liquid, and concretes upon cooling a solid mass, with a coarsely radiating fracture. This has got the unmeaning ɜs of sal-prunelle and mineral crystal. At a red heat, nitre gives out at first a : deal of pretty pure oxygen gas; but afterwards nitrous acid fumes, while potash ins in the retort. It is soluble in 7 parts of water at 32°; in about 3¼ at 60° F., ss than half a part at 194°, and in four tenths at 212°. It is very slightly soluble irit of wine, and not at all in absolute alcohol. It causes a powerful deflagration ı thrown upon burning coals; and when a mixture of it with sulphur is thrown into l-hot crucible, a very vivid light is emitted. Its constituents are, 46·55 potash, and 5 nitric acid.

tre is applied to many purposes:—1. to the manufacture of gunpowder; 2. to that lphuric acid; 3. to that of nitric acid, though nitrate of soda or cubic nitre has lately reded this use of it to a considerable extent; 4. to that of flint-glass; 5. it is used edicine; 6. for many chemical and pharmaceutical preparations; 7. for procuring eflagration with charcoal or cream of tartar, pure carbonate of potash, as also black white fluxes; 8. for mixing with salt in curing butcher meat; 9. in some countries prinkling in solution upon grain, to preserve it from insects; 10. for making fire-ts. See FIRE-WORKS.

ı account of the quantities of Saltpetre and Cubic Nitre imported into, exported from retained for consumption in the United Kingdom. Duty 6d. per cwt:—

Imported in			Exported in			Retained for consumption in		
1835.	1836.	1837.	1835.	1836.	1837.	1835.	1836.	1837.
. 264,338;	279,902;	349,993.	73,379;	38,414;	93,024.	204,580;	242,131;	256,969.

aty received in 1837, £6,424.

ITRATE OF SILVER (*Nitrate d'argent*, Fr.; *Silbersalpeter*, Germ.), is pre-d by saturating pure nitric acid of specific grav. 1·25 with pure silver, evaporating solution, and crystallizing the nitrate. When the drained crystals are fused in a na capsule, and cast into slender cylinders in silver moulds, they constitute the r caustic of the surgeon. This should be white, and unchangeable by light. It is uescent in moist air. The crystals are colorless, transparent 4 and 6 sided tables; possess a bitter, acrid, and most disagreeable metallic taste; they dissolve in their weight of cold, and in much less of hot water; are soluble in four parts of boiling iol, but not in nitric acid; they deflagrate on redhot coals, like all the nitrates; detonate with phosphorus when the two are struck together upon an anvil. They ist of 68·2 of oxyde, and 31·8 of acid. Nitrate of silver, when swallowed, is a very getic poison; but it may be readily counteracted, by the administration of a dose ea-salt, which converts the corrosive nitrate into the inert chloride of silver. ial matter, immersed in a weak solution of neutral nitrate of silver, will keep anged for any length of time; and so will polished iron or steel. Nitrate of r is such a delicate reagent of hydrochloric or muriatic acid, as to show by a ible cloud, the presence of one 113 millionth part of it, or one 7 millionth part of alt in distilled water. It is much used under the name of indelible ink, for ing upon linen with a pen; for which purpose one drachm of the fused salt should be lved in three quarters of an ounce of water, adding to the solution as much water mmonia as will re-dissolve the precipitated oxyde, with sap-green to color it, and -water to make the volume amount to one ounce. Traces written with this liquid ld be first heated before a fire to expel the excess of ammonia, and then exposed to sun-beam to blacken. Another mode of using nitrate of silver as an indelible ink, imbue the linen first with solution of carbonate of soda, to dry the spot, and write ı it with a solution of nitrate of silver, thickened with gum, and tinted with sap-n.

ITRATE OF SODA, *Cubical Nitre* (*Nitrate de soude*, Fr.; *Würfelsalpeter*, n.), occurs under the nitre upon the lands in Spain, India, Chile, and remarkably 'eru, in the districts of Atacama and Taracapa, where it forms a bed several feet t. It appears in several places upon the surface, and extends over a space of more 40 leagues, approaching near to the frontiers of Chile. It is sometimes efflo-ent, sometimes crystallized, but oftener confusedly mixed with clay and sand. ı immensely valuable deposite is only three days' journey from the port of Con-ion in Chile, and from Iquiqui, another harbor situated in the southern part of l.

itrate of soda may be artificially prepared by neutralizing nitric acid with soda, and allizing the solution. It crystallizes in rhomboids, has a cooling, pungent, bitterish ι, less disagreeable than nitre; it becomes moist in the air; dissolves in 3 parts of r at 60° F., in less than 1 part of boiling water; deflagrates more slowly than nitre, with an orange yellow flame. It consists, in its dry state, of 36·6 soda and 63·4 nitric acid; but its crystals contain one prime equivalent of water; hence they are composed of, acid 56·84, base 33·68, water 9·47.

It is susceptible of the same applications as nitre, with the exception of making gunpowder; for which it is not adapted, on account of its deliquescent property.

NITRATE OF STRONTIA. (*Nitrate de Strontiane*, Fr.; *Salpetersaürer strontian*, Germ.) This salt is usually prepared from the sulphuret of strontium, obtained by decomposing sulphate of strontia with charcoal, by strong ignition of the mixed powders in a crucible. This sulphuret being treated with water, and the solution being filtered, is to be neutralized with nitric acid, as indicated by the test of turmeric paper; care being taken to avoid breathing the noxious sulphureted hydrogen gas, which is copiously disengaged. The neutral nitrate being properly evaporated and set aside, affords colorless, transparent, slender octahedral crystals. It has a cooling, yet somewhat acrid taste; is soluble in 5 parts of cold, and in one half part of boiling water, as also in alcohol; is permanent in the air, deflagrates upon burning coals, gives off oxygen when calcined, and leaves caustic strontia. The salt consists of 48·9 strontia and 51·1 nitric acid. That salt is anhydrous; but there is another variety of it, which contains nearly 40 per cent. of water of crystallization, which occurs in large octahedrons. This is preferred for fireworks, because by efflorescence it is easily obtained in a fine powder, which mixes more intimately with the chlorate of potash and charcoal, for the composition of the brilliant red fires, now so much admired in theatrical conflagrations.

NITRIC ACID, *Aquafortis* (*Acide nitrique*, Fr.; *Salpetersaüre*, Germ.), exists, in combination with the bases, potash, soda, lime, magnesia, in both the mineral and vegetable kingdoms. This acid is never found insulated. It was distilled from saltpetre so long ago as the 13th century, by igniting that salt, mixed with copperas or clay, in a retort. Nitric acid is generated when a mixture of oxygen and nitrogen gases, confined over water or an alkaline solution, has a series of electrical explosions passed through it. In this way the salubrious atmosphere may be converted into corrosive aquafortis. When a little hydrogen is introduced into the mixed gases, standing over water, the chemical agency of the electricity becomes more intense, and the acid is more rapidly formed from its elements, with the production of some nitrate of ammonia.

Nitric acid is usually made on the small scale by distilling, with the heat of a sand-bath, a mixture of 3 parts of pure nitre, and 2 parts of strong sulphuric acid, in a large glass retort, connected by a long glass tube with a globular receiver surrounded by cold water. By a well-regulated distillation, a pure acid, of specific gravity 1·500, may be thus obtained, amounting in weight to about two thirds of the nitre employed. To obtain easily the whole nitric acid, equal weights of nitre and concentrated sulphuric acid may be taken; in which case but a moderate heat need be applied to the retort. The residuum will be bisulphate of potash. When only the single equivalent proportion of sulphuric acid is used, namely, 48 parts for 100 of nitre, a much higher heat is required to complete the distillation, whereby more or less of the nitric acid is decomposed, while a compact neutral sulphate of potash is left in the retort, very difficult to remove by solution in water, and therefore apt to destroy the vessel.

Aquafortis is manufactured upon the great scale in iron pots or cylinders of the same construction as I have described under muriatic acid. The more concentrated the sulphuric acid is, the less corrosively will it act upon the metal; and it is commonly used in the proportion of one part by weight to two of nitre. The salt being introduced into the cool retort, and the lid being luted tight, the acid is to be slowly poured in through the aperture *f*, *fig.* 748; while the aperture *g* is connected by a long glass tube with a range of balloons inserted into each other, and laid upon a sloping bed of sand. The bottle *i*, with 3 tubulures partly filled with water, which is required for condensing muriatic acid gas, must, for the present purpose, be replaced by a series of empty receivers, either of glass or salt-glazed stoneware. The cylinders should be only half filled, and be worked off by a gradually raised heat.

Commercial aquafortis is very generally contaminated with sulphuric and muriatic acids, as also with alkaline sulphates and muriates. The quantity of these salts may be readily ascertained by evaporating in a glass capsule a given weight of the aquafortis; while that of the muriatic acid may be determined by nitrate of silver; and of sulphuric acid, by nitrate of baryta. Aquafortis may be purified in a great measure, by re-distillation at a gentle heat; rejecting the first liquid which comes over, as it contains the chlorine impregnation; receiving the middle portion as genuine nitric acid; and leaving a residuum in the retort, as being contaminated with sulphuric acid.

Since nitrate of soda has been so abundantly imported into Europe from Peru, it has been employed by many manufacturers in preference to nitre for the extraction of nitric acid, because it is cheaper, and because the residuum of the distillation, being sulphate of soda, is more readily removed by solution from glass retorts, when a range of these set in a gallery furnace is the apparatus employed. Nitric acid of specific gravity 1·47 may be obtained colorless; but by further concentration a portion of it is decomposed whereby some nitrous acid is produced, which gives it a straw-yellow tinge. At this strength it exhales white or orange fumes, which have a peculiar, though not very disagreeable smell; and even when largely diluted with water, it tastes extremely sour. The greatest density at which it can be obtained is 1·51 or perhaps 1·52, at 60° F., in which state, or even when much weaker, it powerfully corrodes all animal, vegetable, and most metallic bodies. When slightly diluted it is applied, with many precautions, to silk and woollen stuffs, to stain them of a bright yellow hue. See CALICO-PRINTING, page 246.

In the dry state, as it exists in nitre, this acid consists of 26·15 parts by weight of azote, and 73·85 of oxygen; or of 2 volumes of the first gas, and 5 volumes of the second.

When of specific gravity 1·5, it boils at about 210° Fahr.; of 1·45, it boils at about 240°; of 1·42, it boils at 253°; and of 1·40, at 246° F. If an acid stronger than 1·420 be distilled in a retort, it gradually becomes weaker; and if weaker than 1·42, it gradually becomes stronger, till it assumes that standard density. Acid of specific gravity 1·485 has no more action upon tin than water has, though when either stronger or weaker it oxydizes it rapidly, and evolves fumes of nitrous gas with explosive violence. In my two papers upon nitric acid published in the fourth and sixth volumes of the Journal of Science (1818 and 1819), I investigated the chemical relations of these phenomena. Acid of 1·420 consists of 1 atom of dry acid, and 4 of water; acid of 1·485, of 1 atom of dry acid, and 2 of water; the latter compound possesses a stable equilibrium as to chemical agency; the former as to calorific. Acid of specific gravity 1·334, consisting of 7 atoms of water, and 1 of dry acid, resists the decomposing agency of light. Nitric acid acts with great energy upon most combustible substances, simple or compound, giving up oxygen to them, and resolving itself into nitrous gas, or even azote. Such is the result of its action upon hydrogen, phosphorus, sulphur, charcoal, sugar, gum, starch, silver, mercury, copper, iron, tin, and most other metals.

A Table of Nitric Acid, by Dr. Ure.

Specific gravity.	Liq. Acid in 100	Dry acid in 100.	Specific gravity.	Liq Acid in 100	Dry acid in 100.	Specific gravity.	Liq. Acid in 100	Dry acid in 100.	Specific gravity.	Liq. Acid in 100	Dry acid in 100.
1·5000	100	79·700	1·4189	75	59·775	1·2947	50	39·850	1·1403	25	19·925
1·4980	99	78·903	1·4147	74	58·978	1·2887	49	39·053	1·1345	24	19·128
1·4960	98	78·106	1·4107	73	58·181	1·2826	48	38·256	1·1286	23	18·331
1·4940	97	77·309	1·4065	72	57·384	1·2765	47	37·459	1·1227	22	17·534
1·4910	96	76·512	1·4023	71	56·587	1·2705	46	36·662	1·1168	21	16·737
1·4880	95	75·715	1·3978	70	55·790	1·2644	45	35·865	1.1109	20	15·940
1·4850	94	74·918	1·3945	69	54·993	1·2583	44	35·068	1·1051	19	15·143
1·4820	93	74·121	1·3882	68	54·196	1·2523	43	34·271	1·0993	18	14·346
1·4790	92	73·324	1·3833	67	53·399	1·2462	42	33·474	1·0935	17	13·549
1·4760	91	72·527	1·3783	66	52·602	1·2402	41	32·677	1·0878	16	12·752
1·4730	90	71·730	1·3732	65	51·805	1·2341	40	31·880	1·0821	15	11·955
1·4700	89	70·933	1·3681	64	51·068	1·2277	39	31·083	1·0764	14	11·158
1·4670	88	70·136	1·3630	63	50·211	1·2212	38	30·286	1·0708	13	10·361
1·4640	87	69·339	1·3579	62	49·414	1·2148	37	29·489	1·0651	12	9·564
1·4600	86	68·542	1·3529	61	48·617	1·2084	36	28·692	1·0595	11	8·767
1·4570	85	67·745	1·3477	60	47·820	1·2019	35	27·895	1·0540	10	7·970
1·4530	84	66·948	1·3427	59	47·023	1·1958	34	27·098	1·0485	9	7·173
1·4500	83	66·155	1·3376	58	46·226	1·1895	33	26·301	1·0430	8	6·376
1·4460	82	65·354	1·3323	57	45·429	1·1833	32	25·504	1·0375	7	5·579
1·4424	81	64·557	1·3270	56	44·632	1·1770	31	24·707	1·0320	6	4·782
1·4385	80	63·760	1·3216	55	43·835	1·1709	30	23·900	1·0267	5	3·985
1·4346	79	62·963	1·3163	54	43·038	1·1648	29	23·113	1·0212	4	3·188
1·4306	78	62·166	1·3110	53	42·241	1·1587	28	22·316	1·0159	3	2·391
1·4269	77	61·369	1·3056	52	41·444	1·1526	27	21·519	1·0106	2	1·594
1·4228	76	60·572	1·3001	51	40·647	1·1465	26	20·722	1·0053	1	0·797

NITROGEN, DEUTOXYDE OF; *Nitrous gas*, *Nitric oxyde* (*Deutoxyde d'azote*, Fr.; *Stichstoffoxyd*, Germ.) is a gaseous body which may be obtained by pouring upon copper or mercury, in a retort, nitric acid of moderate strength. The nitrous gas comes over in abundance without the aid of heat, and may be received over water freed from air, or over mercury, in the pneumatic trough. It is elastic and colorless; what taste and smell it possesses are unknown, because the moment it is exposed to the mouth or nostrils, it absorbs atmospherical oxygen, and becomes nitrous or nitric acid. Its specific gravity is 1·0393, or 1·04; whence 100 cubic inches weigh 36·66 gr. Water condenses not more than $\frac{1}{20}$ of its volume of this gas. It extinguishes animal life, and the flame of many combustibles; but of phosphorus well kindled, it brightens the flame in a most remarkable degree. It consists of 47 parts of nitrogen gas, and 53 of oxygen gas, by weight;

and of equal parts in bulk, without any condensation; so that the specific gravity of deutoxyde of nitrogen is the arithmetical mean of the two constituents. The constitution of this gas, and the play of affinities which it exercises in the formation of sulphuric acid, are deeply interesting to the chemical manufacturer.

The Hyponitrous acid (*Salpetrigesaüre*, Germ.), like the preceding compound, deserves notice here, on account of the part it plays in the conversion of sulphur into sulphuric acid, by the agency of nitre. It is formed by mingling four volumes of deutoxyde of nitrogen with one volume of oxygen; and appears as a dark orange vapor which is condensable into a liquid at a temperature of 4°— zero, Fahr. When distilled, this liquid leaves a dark yellow fluid. The pure hyponitrous acid consists of 37·12 nitrogen, and 62·88 oxygen; or of two volumes of the first, and three of the second. Water converts it into nitric acid and deutoxyde of nitrogen; the latter of which escapes with effervescence. This acid oxydizes most combustible bodies with peculiar energy; and though its vapor does not operate upon dry sulphurous acid, yet, through the agency of steam, it converts it into sulphuric acid, itself being simultaneously transformed into deutoxyde of nitrogen; ready to become hyponitrous acid again, and to perform a circulating series of important metamorphoses. See SULPHURIC ACID.

NITROGEN GAS, or AZOTE (Eng. and Fr.; *Stickstoffgas*, Germ.), constitutes about 79 hundredths of the bulk of the atmospheric air; it is copiously disengaged from several mineral springs, as from the natural basins of hot water which supply the baths of Leuk, near the Gemmi in Switzerland, and from other springs, in the Pyrenees, in Ceylon, South and North America, &c. It exists also in flesh and most animal substances, as well as in some vegetable products, being one of their essential constituents. When phosphorus is burnt within a jar filled with air, standing over water in the pneumatic trough, it consumes or absorbs the oxygen, and leaves nitrogen, which may be rendered pure by agitation with water. By exposing nitrite of ammonia to heat in a retort, nitrogen comes over alone in great abundance; for the hydrogen of the ammonia is sufficient to saturate the oxygen of the acid, and to convert it into water; while the nitrogen of both constituents is set at liberty. By transmitting chlorine through water of ammonia, or digesting lean flesh in warm nitric acid, nitrogen may also be obtained. This permanently elastic gas is destitute of color, taste, and smell; it has a specific gravity of 0·976, air being 1·000. Hence 100 cubic inches of it weigh 29·7 gr. It extinguishes all burning bodies, and when respired without oxygen is fatal to animal life.

NITROGEN, PROTOXYDE OF, *Nitrous oxyde* (*Protoxyde d'azote*, Fr.; *Stickstoffoxydul*, Germ.), is a gas which displays remarkable powers when breathed, causing in many persons unrestrainable feelings of exhilaration, whence it has been called the laughing or intoxicating gas. It is prepared by exposing crystallized nitrate of ammonia to a heat of about 350° Fahr. in a glass retort. It is much denser than the air of the atmosphere, having a spec. grav. of 1·527; whence 100 cubic inches weigh 46·6 grains. It consists of 63·64 parts of nitrogen, and 36·36 of oxygen, by weight; or of two volumes of nitrogen and one volume of oxygen, condensed by reciprocal attraction into two volumes. It is colorless, and possesses all the mechanical properties of the atmosphere. Water previously freed from air absorbs its own volume of this gas; and thus affords a ready criterion for estimating its freedom from incondensable gases, as oxygen, nitrogen, and its deutoxyde. Several combustibles burn in this gas with an enlarged blue and very vivid flame; and it relumes a taper which has been blown out, provided its tip be red-hot. By powerful pressure it may be liquefied. See GAS.

NITRO-MURIATIC ACID, *Aqua regia* (*Acide nitro-muriatique*, Fr.; *Salpeter salzsaüre*, *Königswasser*, Germ.) is the compound menstruum invented by the alchemists for dissolving gold. If strong nitric acid, orange-colored by saturation with nitrous gas (deutoxyde of azote), be mixed with the strongest liquid muriatic acid, no other effect is produced than might be expected from the action of nitrous acid of the same strength upon an equal quantity of water; nor has the mixed acid so formed any power of acting upon gold or platina. But if colorless aquafortis and ordinary muriatic acid be mixed together, the mixture immediately becomes yellow, and acquires the power of dissolving these two noble metals. When gently heated, pure chlorine gas rises from it, and its color becomes deeper; when further heated, chlorine still rises, but now mixed with nitrous acid gas. If the process has been very long continued, till the color becomes very dark, no more chlorine can be procured, and the liquor has lost the power of dissolving gold. It then consists of nitrous and muriatic acids. It appears, therefore, that aqua regia owes its peculiar properties to the mutual decomposition of the nitric and muriatic acids; and that water, chlorine, and nitrous acid gas are the results of that reaction. Aqua regia does not, strictly speaking, oxydize gold and platinum; it causes merely their combination with chlorine. It may be composed of very different proportions of the two acids; the nitric being commonly of specific gravity 1·34; the muriatic, of specific gravity 1·18 or 1·19. Sometimes 3 parts, and at others 6 parts of the muriatic acid are mixed with 1 of nitric; and occasionally sariate of ammonia, instead of muriatic acid, is added to nitric acid for particular purposes, as for making a solution of tin for the dyers. An aqua regia may also be prepared by dissolving nitre in muriatic acid.

NITROUS ACID (*Acide nitreux*, Fr.; *Salpetrige salpetersaüre*, Germ.) may be procured by distilling, in a coated glass retort, perfectly dry nitrate of lead, into a glass receiver surrounded with a freezing mixture. The acid passes over in vapor, and condenses into a liquid; oxygen gas escapes through the safety tube; while oxyde of lead remains in the bottom of the retort. Nitrous acid may also be obtained by distilling strong fuming nitric acid, at the lowest possible temperature, and rectifying what comes over. At 4°—zero, Fahr., this acid is colorless; at 32° it is wax yellow; at 60° it has an orange hue. It possesses a strong smell, has a very pungent, acrid, sour taste, and a specific gravity of 1·42. It powerfully decomposes organic bodies, staining them yellow. It boils at 82° Fahr. with the disengagement of red or orange fumes. Its constituents are, 41·34 of hyponitrous acid, and 58·66 of anhydrous nitric acid; or ultimately, 30·68 nitrogen = 1 volume, and 69·32 oxygen = 2 volumes. In its other habitudes, it is quite analogous to hyponitrous acid.

A mixture of this double or compound acid with nitric acid, constitutes the orange-brown fuming nitrous acid of the British apothecaries.

The hyponitrous and nitrous are two acids remarkable for containing no water in their composition; being therefore *dry liquids*.

NOPAL is the Mexican name of the plant *cactus opuntia*, upon which the cochineal insect breeds.

NUTMEG (*Muscade*, Fr.; *Muskatennuss*, Germ.) is the fruit of the *myristica moschata*, a beautiful tree of the family of the *laurineæ* of Jussieu, which grows in the Molucca islands. All the parts of this tree are very aromatic; but only those portions of the fruit called mace and nutmeg are sent into the market. The entire fruit is a species of *drupa*, of an ovoid form, of the size of a peach, and furrowed longitudinally. The nutmeg is the innermost kernel, or seed, contained in a thin shell, which is surrounded by the mace; and this again is enclosed in a tough fleshy skin, which opening at the tip, separates into two valves. The nutmeg tree yields three crops annually; one in April, which is the best; one in August; and one in December.

Good nutmegs should be dense, and feel heavy in the hand. When they have been perforated by worms, they feel light, and though the holes have been fraudulently stopped, the unsound ones may easily be detected by this criterion.

Nutmegs afford two oily products. 1. Butter of nutmeg, vulgarly called oil of mace, is obtained in the Moluccas, by expression, from the fresh nutmegs, to the amount of 50 per cent. of their weight. It is a reddish yellow butter-like substance, interspersed with light and dark streaks, and possesses the agreeable smell and taste of the nutmeg, from the presence of a volatile oil. It consists of two fats; one reddish and soft, soluble in cold alcohol; another white and solid, soluble in hot alcohol. 2. The volatile oil is solid, or a *stearoptène*, and has been styled *Myristicine*.

NUT OIL. See Oils, Unctuous.

NUX, VOMICA, a poisonous nut, remarkable for containing the vegeto-alkali Strychnia.

O.

OAK BARK. See Tan.

OATS. (*Avoine*, Fr.; *Hafer*, Germ.) The composition of oats is less known than that of the other *Cerealia*. Vogel found that 100 parts of oats afforded 66 parts of flour or meal, and 34 parts of bran; but this proportion would depend upon the quality of the grain. The flour contains 2 parts of a greenish-yellow fat oil; 8 25 of bitterish sweet extractive; 2·5 of gum; 4·30 of a gray substance, more like coagulated albumen than gluten; 59 of starch; 21 of moisture (inclusive of the loss). Schrader found in the ashes of oats, silica, carbonate of lime, carbonate of magnesia, alumina, with oxydes of manganese and iron.

OBSIDIAN is a glassy looking mineral, with a large conchoidal fracture, and of a blackish color, which froths much at the blow-pipe before it melts into a white enamel.

OCHRE, *yellow and brown* (*Ocre*, Fr.; *Ocker*, Germ.), is a native earthy mixture of silica and alumina, colored by oxyde of iron, with occasionally a little calcareous matter and magnesia. Ochre occurs in beds some feet thick, which lie generally above the oolite, are covered by sandstone and quartzose sands more or less ferruginous, and are accompanied by gray plastic clays, of a yellowish or reddish color; all of them substances which contribute more or less to its formation. The ochry earths are prepared for use by grinding under edge millstones, and elutriation. The yellow ochres may be easily rendered red or reddish brown by calcination in a reverberatory oven, which oxydizes their iron to a higher degree.

Native red ochre is called red chalk and reddle in England. It is an intimate mixture of clay and red iron ochre; is massive; of an earthy fracture; is brownish-red, blood-red, stains and writes red. The oxyde of iron is sometimes so considerable, that the ochre may be reckoned an ore of that metal.

The ochre beds of England are in the iron sand, the lowest of the formations which intervene between the chalk and oolites. Beds of fuller's earth alternate with the iron sand. The following is a section of the ochre pits at Shotover Hill, near Oxford:—

Beds of highly ferruginous grit, forming the summit of the hill .	6 feet.
Gray sand	3 do.
Ferruginous concretions	1
Yellow sand	6
Cream colored loam	4
Ochre	0 6 inches.

Beneath this, there is a second bed of ochre, separated by a thin bed of clay.

Bole, or Armenian bole; called also Lemnian earth, and terra sigillata, because when refined it was stamped with a seal; is massive, with a conchoidal fracture, a feeble lustre, reddish-yellow or brown, a greasy feel; adheres to the tongue, spec. grav. 1·4 to 2·0. It occurs in the island Stalimene (the ancient Lesbos), and in several other places, especially at Sienna; whence the brown pigment called *terra di Siena*.

OILS (*Huiles*, Fr.; *Oele*, Germ.), are divisible into two great classes: the fat or fixed oils, *huiles grasses*, Fr.; *Fette oele*, Germ.; and the essential or volatile oils, *Huiles volatiles*, Fr.; *Flüchtige, aetherische oele*, Germ. The former are usually bland and mild to the taste; the latter hot and pungent. The term distilled, applied also to the last class, is not so correct, since some of them are obtained by expression, as the whole of the first class may be, and commonly are.

All the known fatty substances found in organic bodies, without reference to their vegetable or animal origin, are, according to their consistence, arranged under the chemical heads of oils, butters, and tallows. They all possess the same ultimate constituents, carbon, hydrogen, and generally oxygen, and in nearly the same proportions.

The fat oils are widely distributed through the organs of vegetable and animal nature. They are found in the seeds of many plants, associated with mucilage, especially in those of the bicotyledinous class, occasionally in the fleshy pulp surrounding some seeds, as the olive; also in the kernels of many fruits, as of the nut and almond tree, and finally in the roots, barks, and other parts of plants. In animal bodies, the oily matter occurs enclosed in thin membraneous cells, between the skin and the flesh, between the muscular fibres, within the abdominal cavity in the omentum, upon the intestines, and round the kidneys, and in a bony receptacle of the scull of the spermaceti whale; sometimes in special organs, as of the beaver; in the gall-bladder, &c., or mixed in a liquid state with other animal matters, as in the milk.

Braconnot, but particularly Raspail, have shown that animal fats consist of small microscopic, partly polygonal, and partly reniform particles, associated by means of their containing sacs. These may be separated from each other by tearing the recent fat asunder, rinsing it with water, and passing it through a sieve. The membranes being thus retained, the granular particles are observed to float in the water, and afterwards to separate, like the globules of starch, in a white pulverulent semi-crystalline form. The particles consist of a strong membraneous skin, enclosing *stearine* and *elaine*, or solid and liquid fat, which may be extracted by trituration and pressure. These are lighter than water, but sink readily in spirit of wine. When boiled in strong alcohol, the oily principle dissolves, but the fatty membrane remains. These granules have different sizes and shapes in different animals; in the calf, the ox, the sheep, they are polygonal, and from $\frac{1}{70}$ to $\frac{1}{450}$ of an inch in diameter; in the hog they are kidney-shaped, and from $\frac{1}{70}$ to $\frac{1}{140}$ of an inch; in man, they are polygonal, and from $\frac{1}{70}$ to $\frac{1}{900}$ of an inch; in insects they are usually spherical, and not more than $\frac{1}{600}$ of an inch.

The following is a list of the Plants which yield the ordinary Unctuous Oils of commerce:

No.	Plants.	Oils.	Spec. gravity.
1.	Linum usitatissum et perenne - D.	Linseed oil - - -	0·9347
2. 3.	Corylcus avellana } Juglans regia } - - D.	Nut oil - - -	0·9260
4.	Papaver somniferum - - D.	Poppy oil - - -	0·9243
5.	Cannabis sativa - - D.	Hemp oil - - -	0·9276

ıe Plants which yield the ordinary Unctuous Oils of commerce—*continued.*

Plants.		Oils.	Spec. gravity.
ıų orientale	G.	Oil of sesamum	
'uropea	G.	Olive oil	0·9176
alus communis	G.	Almond oil	0·9180
dina mohringa	G.	Oil of behen or ben	
›ita pepo, and melapepo	D.	Cucumber oil	0·9231
silvatica	G.	Beech oil	0·9225
nigra et arvensis	G.	Oil of mustard	0·9160
thus annuus et perennis	D.	Oil of sunflower	0·9262
·a napus et campestris	G.	Rape-seed oil	0·9136
s communis	D.	Castor oil	0·9611
.na tabacum et rustica	D.	Tobacco-seed oil	0·9232
domestica	G.	Plum-kernel oil	0·9127
inifera	D.	Grape-seed oil	0·9202
'oma cacao	G.	Butter of cacao	0·892
ıucifera	G.	Cocoa-nut oil	
butyracea vel avoira elais	G.	Palm oil	0·968
nobilis	G.	Laurel oil	
s hypogæa	G.	Ground-nut oil	
indica	G.	Piney tallow	0·926
ıs matronalis	D.	Oil of Julienne	0·9281
ıın sativa	D.	Oil of camelina	0·9252
luteola	D.	Oil of weld-seed	0·9358
ım sativum	D.	Oil of garden cresses	0·9240
belladonna	D.	Oil of deadly nightshade	0·9250
ium Barbadense	D.	Cotton-seed oil	
a campestris oleifera	G.	Colza oil	0·9136
a præcox	G.	Summer rape-seed oil	0·9139
ıus sativus oleifer	G.	Oil of radish-seed	0·9187
cerasus	G.	Cherry-stone oil	0·9239
nalus	G.	Apple-seed oil	
nus Europæus	G.	Spindle-tree oil	0·9380
sanguinea	G.	Cornil-berry tree oil	
s esculenta	G.	Oil of the roots of cyper grass	0·9180
mus niger	G.	Henbane-seed oil	0·9130
ıs hippocastanum	G.	Horse-chestnut oil	0·927
bies	D.	Pinetop oil	0·285

are contained in that part of the seed which gives birth to the cotyledons;
›und in the plumula and radicle. Of all the families of plants, the cruci-
:hest in oleiferous seeds; and next to that are the drupaceæ, amentaceæ,
The seeds of the gramineæ and leguminosæ contain rarely more than a
l. One root alone, that of the *cyperus esculenta*, contains a fat oil. The
l furnished by seeds varies not only with the species, but in the same seed,
nd climate. Nuts contain about half their weight of oil; the seeds of the
ca and campestris, one third; the variety called colza in France, two fifths;
fourth; and linseed from one fourth to one fifth. Unverdorben states that a
ırters of linseed yields 40 ahms=120 gallons English of oil; which is about
er quarter.

s, when first expressed without much heat, taste merely unctuous on the
thale the odor of their respective plants. They appear quite neutral by lit-
Their fluidity is very various, some being solid at ordinary temperatures, and
ing fluid at the freezing point of water. Linseed oil indeed does not con-
:d from 4° to 18° below 0° F. The same kind of seed usually affords oils
grees of fusibility; so that in the progress of refrigeration one portion con-
ınother. Chevreul, who was the first to observe this fact, considers all the
posed of two species, one of which resembles *suet*, and was thence styled by
and another which is liquid at ordinary temperatures, and was called *elaine*,
refrigeration and pressure between the folds of blotting paper, or in linen
part is separated, and the solid remains. By heating the paper in water,
nay be obtained separate. When alcohol is boiled with the natural oil, the
f the stearine remains undissolved.

Oleine may also be procured by digesting the oil with a quantity of caustic soda equal to one half of what is requisite to saponify the whole; the stearine is first transformed into soap, then a portion of the oleine undergoes the same change, but a great part of it remains in a pure state. This process succeeds only with recently expressed or very fresh oils. The properties of these two principles of the fat oils vary with the nature of the respective oils, so that the sole difference does not consist, as many suppose, in the different proportions of these two bodies, but also in peculiarities of the several stearines and oleines, which, as extracted from different seeds, solidify at very different temperatures.

In close vessels, oils may be preserved fresh for a very long time, but with contact of air they undergo progressive changes. Certain oils thicken and eventually dry into a transparent, yellowish, flexible substance; which forms a skin upon the surface of the oil, and retards its further alteration. Such oils are said to be *drying* or *siccative*, and are used on this account in the preparation of varnishes and painters' colors. Other oils do not grow dry, though they turn thick, become less combustible, and assume an offensive smell. They are then called *rancid.* In this state, they exhibit an acid reaction, and irritate the fauces when swallowed, in consequence of the presence of a peculiar acid, which may be removed in a great measure by boiling the oil along with water and a little common magnesia for a quarter of an hour, or till it has lost the property of reddening litmus. While oils undergo the above changes, they absorb a quantity of oxygen equal to several times their volume. Saussure found that a layer of nut oil, one quarter of an inch thick, enclosed along with oxygen gas over the surface of quicksilver in the shade, absorbed only three times its bulk of that gas in the course of eight months; but when exposed to the sun in August, it absorbed 60 volumes additional in the course of ten days. This absorption of oxygen diminished progressively, and stopped altogether at the end of three months, when it had amounted to 145 times the bulk of the oil. No water was generated, but 21·9 volumes of carbonic acid were disengaged, while the oil was transformed in an anomalous manner into a gelatinous mass, which did not stain paper. To a like absorption we may ascribe the elevation of temperature which happens when wool or hemp, besmeared with olive or rapeseed oil, is left in a heap; circumstances under which it has frequently taken fire, and caused the destruction of both cloth-mills and dock-yards.

In illustration of these accidents, if paper, linen, tow, wool, cotton, mats, straw, wood shavings, moss, or soot, be imbued slightly with linseed or hempseed oil, and placed in contact with the sun and air, especially when wrapped or piled in a heap, they very soon become spontaneously hot, emit smoke, and finally burst into flames. If linseed oil and ground manganese be triturated together, the soft lump so formed will speedily become firm, and ere long take fire.

The fat oils are completely insoluble in water. When agitated with it, the mixture becomes turbid, but if it be allowed to settle the oil collects by itself upon the surface. This method of washing is often employed to purify oils. Oils are little soluble in alcohol, except at high temperatures. Castor oil is the only one which dissolves in cold alcohol. Ether, however, is an excellent solvent of oils, and is therefore employed to extract them from other bodies in analysis; after which it is withdrawn by distillation.

Fat oils may be exposed to a considerably high temperature, without undergoing much alteration; but when they are raised to nearly their boiling point, they begin to be decomposed. The vapors that then rise are not the oil itself, but certain products generated in it by the heat. These changes begin somewhere under 600° of Fahr., and require for their continuance temperatures always increasing. The products consist at first in aqueous vapor, then a very inflammable volatile oil, which causes boiling oil to take fire spontaneously; and next carbureted hydrogen gas, with carbonic acid gas. In a lamp, a small portion of oil is raised in the wick by capillarity, which being heated, boils and burns. See ROSIN-GAS.

Several fat oils, mixed with one or two per cent. of sulphuric acid, assume instantly a dark green or brown hue, and, when allowed to stand quietly, deposite a coloring matter after some time. It consists in a chemical combination of the sulphuric acid, with a body thus separated from the oil, which becomes in consequence more limpid, and burns with a brighter flame, especially after it is washed with steam, and clarified by repose or filtration. Any remaining moisture may be expelled by the heat of a water bath.

The oils combine with the salifiable bases, and give birth to the substance called *glycerine* (the sweet principle), and to the margaric, oleic, and stearic acids. The general product of their combination with potash or soda, is SOAP, which see. Caustic ammonia changes the oils very difficultly and slowly into a soap; but it readily unites with them into a milky emulsion called volatile liniment, used as a rubefacient in medicine. Upon mixing water with this liquor, the oil separates in an unchanged state. By longer contact, ammonia acts upon oils like the other alkalis. Sea salt dissolves in small quantity in the oils, and so does verdigris. The latter solution is green. Oils dissolve also several of the vegetable alkalis, as morphia, cinchonia, quinia, strychia, and delphia.

Olive oil consists of 77·2 carbon, 13·4 hydrogen, and 9·4 oxygen, in 100 parts. Spermaceti oil, by my analysis, of 78·9 carbon, 10·97 hydrogen, and 10·13 oxygen.

Castor oil do. - - -	74·0	10·3	15·7	azote,	
Stearine of olive oil -	82·17	11·23	6·30	0·30	*Saussure.*
Oleine of do. - - -	76·03	11·54	12·07	0·35	do.
Linseed oil - - -	76·01	11·35	12·64		do.
Nut oil - - - -	79·77	10·57	9·12	0·54	do.
Oil of almonds - -	77·40	11·48	10·83	0·29	

De Saussure concludes that the less fusible fats contain more carbon and less oxygen, and that oils are more soluble in alcohol, the more oxygen they contain.

I shall now take a short view of the peculiarities of the principal expressed oils.

Oil of almonds, according to Gusseron, contains no stearine; at least he could obtain none by cooling it and squeezing it successively till it all congealed. Braconnot had, on the contrary, said, that it contains 24 per cent. of stearine. I believe that Gusseron is right, and that Braconnot had made fallacious experiments on an impure oil.

Oil of colza is obtained from the seeds of *brassica campestris*, to the amount of 39 per cent. of their weight. It forms an excellent lamp oil, and is much employed in France.

The *corylus avellana* furnishes in oil 60 per cent. of the weight of the nuts.

Hempseed oil resembles the preceding, but has a disagreeable smell, and a mawkish taste. It is used extensively for making both soft soap and varnishes.

Linseed oil is obtained in greatest purity by cold pressure; but by a steam heat of about 200° F. a very good oil may be procured in larger quantity. The proportion of oil usually stated by authors is 22 per cent. of the weight of the seed; but Mr. Blundell informs me, that, by his plan of hydraulic pressure, he obtains from 26 to 27. In the Encyclopædia Metropolitana, under *Oil Press*, a quarter of seed (whose average weight is 400 lbs.) is said to yield 20 gallons of oil. Now as the gallon of linseed oil weighs 9·3 lbs., the total product will be 186 lbs., which amounts to more than 45 per cent.—an extravagant statement, about double the ordinary product in oil mills. Even supposing the gallons not to be imperial, but old English, we should have upwards of 38 per cent. of oil by weight, which is still an impossible quantity. Such are the errors introduced into respectable books, by adopting without practical knowledge, the puffing statements of a patentee. It dissolves in 5 parts of boiling alcohol, in 40 parts of cold alcohol, and in 1·6 parts of ether. When kept long cool in a cask partly open, it deposites masses of white stearine along with a brownish powder. That stearine is very difficult of saponification.

Mustard-seed oil. The white or yellow seed affords 36 per cent. of oil, and the black seed 18 per cent. The oil concretes when cooled a little below 32° F.

Nut oil is at first greenish colored, but becomes pale yellow by time. It congeals at the same low temperature as linseed oil, into a white mass, and has a more drying quality than it.

Oil of olives is sometimes of a greenish and at others of a pale yellow color. A few degrees above 32° F. it begins to deposite some white granules of stearine, especially if the oil have been originally expressed with heat. At 22° it deposites 28 per cent. of its weight in stearine, which is fusible again at 68°, and affords 72 per cent. of oleine. According to Kerwych, oleine of singular beauty may be obtained by mixing 2 parts of olive oil with 1 part of caustic soda ley, and macerating the mixture for 24 hours with frequent agitation. Weak alcohol must then be poured into it, to dissolve the stearine soap, whereby the oleine, which remains meanwhile unsaponified, is separated, and floats on the surface of the liquid. This being drawn off, a fresh quantity of spirits is to be poured in, till the separation of all the oleine be completed. It has a slightly yellowish tint, which may be removed by means of a little animal charcoal mixed with it in a warm place for 24 hours. By subsequent filtration, the oleine is obtained limpid and colorless, of such quality that it does not thicken with the greatest cold, nor does it affect either iron or copper instruments immersed in it.

There are three kinds of olive oil in the market. The best, called virgin salad oil, is obtained by a gentle pressure in the cold; the more common sort is procured by stronger pressure, aided with the heat of boiling water; and thirdly, an inferior kind, by boiling the olive residuum or *marc*, with water, whereby a good deal of mucilaginous oil rises and floats on the surface. The latter serves chiefly for making soaps. A still worse oil is got by allowing the mass of bruised olives to ferment before subjecting it to pressure.

Oil of olives is refined for the watchmakers by the following simple process. Into a bottle or vial containing it, a slip of sheet lead is immersed, and the bottle is placed at a window, where it may receive the rays of the sun. The oil by degrees gets covered with a curdy mass, which after some time settles to the bottom, while itself becomes limpid and colorless. As soon as the lead ceases to separate any more of that white substance, the oil is decanted off into another vial for use.

Palm oil melts at 117·5° F., and is said to consist of 31 parts of stearine and 69 of oleine in 100. It becomes readily rancid by exposure to air, and is whitened at the same time.

The oil extracted from the plucked tops of the *pinus abies*, in the Black Forest in Germany, is limpid, of a golden yellow color, and resembles in smell and taste the oil of turpentine. It answers well for the preparation of varnishes.

The *oil of plum-stones* is made chiefly in Wurtemberg, and is found to answer very well for lamps.

Poppy-seed oil has none of the narcotic properties of the poppy juice. It is soluble in ether in every proportion.

Rape-seed oil has a yellow color, and a peculiar smell. At 25° F. it becomes a yellow mass, consisting of 46 parts of stearine, which fuses at 50°, and 54 of oleine, in which the smell resides.

The *oils of belladonna seeds*, and *tobacco seeds*, are perfectly bland. The former is much used for lamps in Swabia and Wurtemburg. The oil-cakes of both are poisonous.

Oil of wine-stones is extracted to the amount of 10 or 11 per cent. from the seeds of the grape. Its color is at first pale yellow, but it darkens with age. It is used as an article of diet.

FAT OIL MANUFACTURE.

It is the practice of almost all the proprietors in the neighborhood of Aix, in Provence, to preserve the olives for 15 days in barns or cellars, till they have undergone a species of fermentation, in order to facilitate the extraction of their oil. If this practice were really prejudicial to the product, as some theorists have said, would not the high reputation and price of the oil of Aix have long ago suffered, and have induced them to change their system of working? In fact, all depends upon the degree of fermentation excited. They must not be allowed to mould in damp places, to lie in heaps, to soften so as to stick to each other, and discharge a reddish liquor, or to become so hot as to raise a thermometer plunged into the mass up to 96° F. In such a case they would afford an acrid nauseous oil, fit only for the woollen or soap manufactories. A slight fermentative action, however, is useful, towards separating the oil from the mucilage. The olives are then crushed under the stones of an edge-mill, and next put into a screw-press, being enclosed in bulrush-mat bags (*cabas*), laid over each other to the number of eighteen. The oil is run off from the channels of the ground-sill, into casks, or into stone cisterns called *pizes*, two thirds filled with water. The pressure applied to the *cabas* should be slowly graduated.

What comes over first, without heat, is the virgin oil already mentioned. The *cabas* being now removed from the press, their contents are shovelled out, mixed with some boiling water, again put in the bags, and pressed anew. The hot water helps to carry off the oil, which is received in other casks or *pizes*. The oil ere long accumlates at the surface, and is skimmed off with large flat ladles; a process which is called *lever l'huile*. When used fresh, this is a very good article, and quite fit for table use, but is apt to get rancid when kept. The subjacent water retains a good deal of oil, by the intervention of the mucilage; but by long repose in a large general cistern, called *l'enfer*, it parts with it, and is then drawn off from the bottom by a plug-hole. The oil which remains after the water is run off, is of an inferior quality, and can be used only for factory purposes.

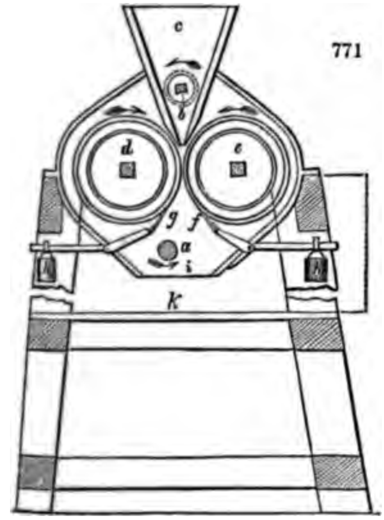
The marc being crushed in a mill, boiled with water, and expressed, yields a still coarser article.

All the oil must be *fined* by keeping in clean tuns, in an apartment heated to the 60th degree Fahr. at least, for twenty days; after which it is run off into strong casks, which are cooled in a cellar, and then sent into the market.

Oil of almonds is manufactured by agitating the kernels in bags, so as to separate their brown skins, grinding them in a mill, then enclosing them in bags, and squeezing them strongly between a series of cast iron plates, in a hydraulic press; without heat at first, and then between heated plates. The first oil is the purest, and least apt to become rancid. It should be refined by filtering through porous paper. Next to olive oil, this species is the most easy to saponify. Bitter almonds, being cheaper than the sweet, are used in preference for obtaining this oil, and they afford an article equally bland, wholesome, and inodorous. But a strongly scented oil may be procured, *according to* M. Planché, by macerating the almonds in hot water, so as to blanch them, then drying them in a stove, and afterwards subjecting them to pressure. The volatile oil of almonds is obtained by distilling the marc or bitter almond cake, along with water. See **Press Hydraulic**, and **Stearine**.

Linseed, rapeseed, poppyseed, and other oleiferous seeds were formerly treated for the extraction of their oil, by pounding in hard wooden mortars with pestles shod with iron, set in motion by cams driven by a shaft turned with horse or water power, then the triturated seed was put into woollen bags which were wrapped up in hair-cloths, and squeezed between upright wedges in press-boxes by the impulsion of vertical rams driven also by a cam mechanism. In the best mills upon the old construction, the cakes obtained by this first wedge pressure were thrown upon the bed of an edge-mill, ground anew and subjected to a second pressure, aided by heat now, as in the first case. These mortars and press-boxes constitute what are called Dutch mills. They are still in very general use both in this country and on the Continent; and are by many persons supposed to be preferable to the hydraulic presses.

The roller-mill, for merely bruising the linseed, &c., previous to grinding it under edge-stones, and to heating and crushing it in a Dutch or a hydraulic oil-mill, is represented in *figs.* 770, and 771. The iron shaft *a*, has a winch at each end, with a heavy fly-wheel upon the one of them, when the machine is to be worked by hand. Upon the opposite end is a pulley, with an endless cord which passes round a pulley on the end of the fluted roller *b*, and thereby drives it. This fluted roller *b*, lies across the hopper *c*, and by its agitation causes the seeds to descend equably through the hopper, between the crushing rollers *d*, *e*. Upon the shaft *a*, there is also a pinion which works into two toothed wheels on the shafts of the crushing cylinders *d* and *e*, thus communicating to these cylinders motion in opposite directions. *f*, *g* are two scraper-blades, which by means of the two weights *h*, *h*, hanging upon levers, are pressed against the surfaces of the cylinders, and remove any seed-cake from them. The bruised seeds fall through the slit *i* of the case, and are received into a chest which stands upon the board *k*.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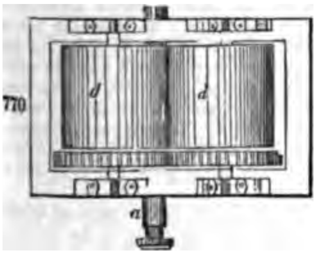
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Machines of this kind are now usually driven by power. Hydraulic presses have been of late years introduced into many seed-oil mills in this country; but it is still a matter of dispute whether they, or the old Dutch oil-mill, with bags of seed compressed between wedges, driven by cam-stamps, be the preferable; that is, afford the largest product of oil with the same expenditure of capital and power. For figures of hydraulic presses, see **Press**, and **Stearine**.

This bruising of the seed is merely a preparation for its proper grinding under a pair of heavy edge stones, of granite, from 5 to 7 feet in diameter; because unbruised seed is apt to slide away before the vertical rolling wheel, and thus escape trituration. The edge-mill, for grinding seeds, is quite analogous to the gunpowder-mill represented in *fig.* 531, page 636. Some hoop the stones with an iron rim, but others prefer, and I think justly, the rough surface of granite, and dress it from time to time with hammers, as it becomes irregular. These stones make from 30 to 36 revolutions upon their horizontal bed of masonry or iron in a minute. The centre of the bed, where it is perforated for the passage of the strong vertical shaft which turns the stones, is enclosed by a circular box of cast iron, firmly bolted to the bed-stone, and furnished with a cover. This box serves to prevent any seeds or powder getting into the step or socket, and obstructing the movement. The circumference of the mill-bed is formed of an upright rim of oak plank, bound with iron. There is a rectangular notch left in the edge of the bed, and corresponding part of the rim, which is usually closed with a slide-plate, and is opened only at the end of the operation, to let the pasty seed-cake be turned out by the oblique arm of the bottom scraper. The two parallel stones, which are set near each other, and travel round their circular path upon the bed, grind the seeds not merely by their weight, of three tons each, but also by a rubbing motion, or attrition; because their periphery being not conical, but cylindrical, by its rolling upon a plane surface, must at every instant turn round with friction upon their resting points. Strong cast-iron boxes are bolted upon the centre of the stones, which by means of screw clamps seize firmly the horizontal iron shafts that traverse and drive them, by passing into a slit-groove the vertical turning shaft. This groove is lined with strong plates of steel, which wear rapidly by the friction, and need to be frequently renewed.

The seeds which have been burst between the rolls, or in the mortars of the Dutch mills, are to be spread as equably as possible by a shovel upon the circular path of the edge-stones, and in about half an hour the charge will be sufficiently ground into a paste. This should be put directly into the press, when fine cold-drawn oil is wanted. But in general the paste is heated before being subjected to the pressure. The pressed cake is again thrown under the edge-stones, and, after being ground the second time, should be exposed to a heat of 212° Fahr., in a proper pan, called a steam-kettle, before being subjected to the second and final pressure in the woollen bags and hair-cloths.

Fig. 772, is a vertical section of the steam-kettle of Hallette, and *fig.* 773 is a view of the seed-stirrer. *a*, is the wall of masonry, upon which, and the iron pillars *b*, the pan is supported. It is enclosed in a jacket, for admitting steam into the intermediate space *d*, *d*, *d*, at its sides and bottom. *c*, is the middle of the pan in which the shaft of the stirrer is planted upright, resting by its lower end in the step *e*; *f*, is an opening, by which the contents of the pan may be emptied; *g*, is an orifice into which the mouth of the hair or worsted bag is inserted, in order to receive the heated seed, when it is turned out by the rotation of the stirrer and the withdrawal of the plug *f* from the discharge aperture; *h*, is the steam induction pipe; and *i*, the eduction pipe, which serves also to run off the condensed water.

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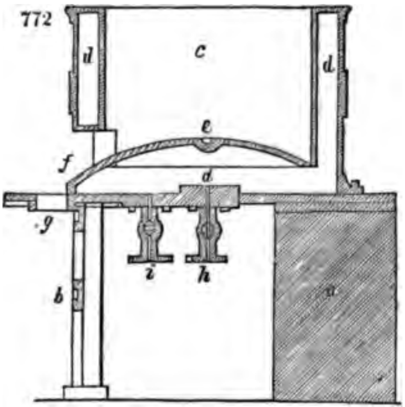

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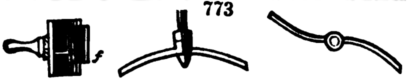

The hydraulic oil-press is generally double; that is, it has two vertical rams placed parallel to each other, so that while one side is under pressure, the other side is being discharged. The bags of heated seed-paste or meal are put into cast-iron cases, which are piled over each other to the number of 6 or 8, upon the press sill, and subjected to a force of 300 or 400 tons, by pumps worked with a steam engine. The first pump has usually 2 or 2½ inches diameter for a ram of 10 inches, and the second pump one inch. Each side of the press, in a well-going establishment, should work 38 pounds of seed-flour every 5 minutes. Such a press will do 70 quarters of linseed in the days' work of one week, with the labor of one man at 20*s*. and three boys at 5*s*. each; and will require a 12-horse power to work it well, along with the rolls and the edge-stones.

I am indebted to my excellent friend Mr. E. Woolsey, for the following most valuable notes, taken by him at sundry mills for pressing oil; and remarks upon the subject of seed-crushing in general.

"The chief point of difference depends upon the quality of seed employed. Heavy seed will yield most oil, and seed ripened under a hot sun, and where the flax is not gathered too green, is the best. The weight of linseed varies from 48 to 52 lbs. per imperial bushel; probably a very fair average is 49 lbs., or 392 lbs. per imperial quarter. I inspected one of the seed-crusher's books, and the average of 15 trials of a quarter each of different seeds in the season averaged 14½ galls. of 7½ lbs. each; say, 109 lbs. of oil per quarter. This crusher, who uses only the hydraulic press, and one pressing, informed me that—

Archangel seed will yield from - - - -	15 to 16 galls. (of 7½ lbs. each)	
Best Odessa - - - - - - - -	18 and even 19 galls.	
Good crushing-seed - - - - - -	15½	do.
Low seed, such as weighs 48 lbs. per bushel -	13½	do.

"The average of the seed he has worked, which he represents to be of an inferior quality, for the sake of its cheapness, yields 14½ galls. per quarter. I had some American seed which weighed 52¼ lbs. per imperial bushel, ground and pressed under my own observation, and it gave me 111 lbs. oil; that is to say, 418 lbs. of seed gave 111 lbs. oil=$26\frac{56}{100}$ per cent. A friend of mine, who is a London crusher, told me the oil varied according to the seed from 14 to 17 galls.; and when you consider the relative value of seeds, and remember that *oil* and *cake* from any kind of seed is of the *same value*, it will be apparent that the yield is very different; for example,

25th July, 1836, prices of seed.	E. India linseed worth 52*s*.			per quarter.
	Petersburg linseed	48	to 52	do.
	Odessa - -	52	—	—

The difference of 4*s*. must be paid for in the quantity of oil, which at 38*s*. 6*d*. per cwt. (the then price) requires about 11½ lbs. more oil expressed to pay for the difference in the market value of the seed. Another London crusher informed me that East India linseed will produce 17 gallons, and he seemed to think that that was the extreme quantity that could be expressed from *any seed*. The average of last year's Russian seed would be about 14 galls.; Sicilian seed 16 galls.

Place.	Engine Power.	Hydraulic Presses.	Stampers.	Rollers.	Edge-stones.	Kettles.	Work done,—reduced to an hour.	Number of pressings.
France	10 horse power	1 hydraulic, 200 tons.	5 light stampers.	1 pair rolls.	1 pr. edge-stones.	5 table kettles small size heated by steam.	1 English quarter per working hour.	2 pressings.
London	20 horse power	1 hydraulic, 800 tons.	13 light stampers.	1 pair rolls.	2 pr. edge-stones.	8 table kettles small size heated by fire.	2 English quarters per working hour.	2 ditto
London	12 horse power, but the engine is used also for other work.	none	9 light stampers.	2 pair rolls, used also for other purposes	2 pr. edge-stones, used also for other purposes.	4 table kettles small size heated by fire.	¾ English quarter per working hour.	2 ditto
Hull	18 horse engine, old construction.	none	3 very heavy stampers.	1 pair rolls.	1 pr. edge-stones.	3 double case large size steam kettles.	1¼ English quarter per working hour.	1 ditto
Ditto	22 horse engine	none	6 very heavy stampers.	2 pair rolls.	2 pr. edge-stones.	6 double case large size steam kettles.	Not known.	1 ditto

"*Rape-seed.*—I have not turned my attention to the quantity of oil extracted from this seed; but a French crusher (M. Geremboret), on whom I think one may place considerable dependance, told me that

3½ lbs. of best Cambray rape-seed yielded	- - -	1 lb. oil.
3¾ — common rape-seed	- - - -	1 lb. oil.
4¼ — — poppy-seed	- - - -	1 lb. oil.

"Rape-seed weighs from 52 to 56 lbs. per imperial bushel."

The following are the heads of a reference of machinery for a seed oil-mill:—

1. Two pairs of cast-iron rollers, 19 inches long, and 10 inches in diameter, fixed in a cast-iron frame, with brasses, wheels, shafts, bolts, scrapers, hoppers, shoes, &c.

2. Two pairs of edge-stones, 7 feet diameter each, with two bottom stones, 6 feet diameter each, cast-iron upright shafts, sweepers, wheels, shafts, chairs, brasses, bolts, and scrapers, with driving spur-wheels, &c.

3. Five steam kettles, with wheels, shafts, and brasses, bolts, breeches, and steam pipes, an upright cast-iron shaft, with chairs and brasses at each end; and a large bevel wheel upon the bottom end of upright shaft, and another, smaller, upon fly-wheel shaft, for the first motions.

4. Five stamper presses, with press plates of cast-iron, cast-iron stamper shaft with 10 arms and 10 rollers, with bosses, brasses, bolts, driving bevel-wheels.

A well made oil-mill, consisting of the above specified parts, will manufacture 200 quarters of seed per week.

I have been assured by practical engineers, conversant in oil-mills, that a double hydraulic press, with 2 ten-inch rams, will do the work of no more than two of the stamper presses; that is to say, it will work 22 quarters in 24 hours; while three stamper presses will work 33 quarters in the same time, and produce one half more oil.

Castor oil, quantity of,

	Imported.	Retained for consumption.	Exported.
Year.	*Cwts.*	*Cwts.*	*Cwts.*
1835.	1,109,307	670,205	61,296
1836.	981,585	809,559	68,515

Duty, from British possessions, 2*s.* 6*d.* per cwt.; from foreign, 1*s.* per lb.

Cocoa-nut oil, quantity of,

	Imported.	Retained for consumption.	Exported.
Year.	*Cwts.*	*Cwts.*	*Cwts.*
1835.	19,838	14,015	2,238
1836.	26,058	26,062	3,158
1837.	41,218	28,836	

Olive oil, quantity of,

	Imported.	Retained for consumption.	Exported.
Year.	*Galls.*	*Galls.*	*Galls.*
1835.	606,166	554,196	283,734
1836.	2,682,016	1,844,622	150,561
1837.	1,720,397	1,499,122	

Duties on olive oil, not of Naples and Sicily, 4*d.*; of Naples and Sicily, 8*d.*; and if in ships of these countries, 10*d.* per gallon.

Train oil, spermaceti, and blubber, quantity of,

	Imported.	Retained for consumption.	Exported.
Year.	*Tuns.*	*Tuns.*	*Tuns.*
1835.	24,197	16,114	8,035
1836.	19,489	18,722	1,365
1837.	21,823	21,286	

Duties on oil taken by British ships, 1*s.*; by foreign fishers, £26 18*s.* per tun.

OILS, VOLATILE OR ESSENTIAL; Manufacture of. The volatile oils occur in every part of odoriferous plants, whose aroma they diffuse by their exhalation; but in different organs of different species. Certain plants, such as thyme and the scented *labiatæ*, in general contain volatile oil in all their parts; but others contain it only in the blossoms, the seeds, the leaves, the root, or the bark. It sometimes happens that different parts of the same plant contain different oils; the orange, for example, furnishes three different oils, one of which resides in the flowers, another in the leaves, and a third in the skin or epidermis of the fruit. The quantity of oil varies not only with the species, but also in the same plant, with the soil, and especially the climate; thus in hot countries it is generated most profusely. In several plants, the volatile oil is contained in peculiar orders of vessels, which confine it so closely that it does not escape in the drying, nor is dissipated by keeping the plants for many years. In other species, and particularly in flowers, it is formed continually upon their surface, and flies off at the moment of its formation.

Volatile oils are usually obtained by distillation. For this purpose the plant is introduced into a still, water is poured upon it, and heat being applied, the oil is volatilized by the aid of the watery vapor, at the temperature of 212°, though when alone it would probably not distil over unless the heat were 100° more. This curious fact was first explained in my *New Researches upon Heat*, published in the Philosophical Transactions for 1818. Most of the essential oils employed in medicine and perfumery are extracted by distillation from dried plants; only a few, such as those of the rose and orange flower, are obtained from fresh or succulent salted plants. When the mingled vapors of the oil and water are condensed into the liquid state, by the refrigerator of the still, the oil separates, and either floats on the surface or sinks to the bottom of the water. Some oils of a less volatile nature require a higher heat than 212° to raise them in vapor, and must be dislodged by adding common salt to the water, whereby the heat being augmented by 15°, they readily come over. If in such distillations too much water be added, no oil will be obtained, because it is partially soluble in water; and thus merely an aromatic water is produced. If on the other hand too little water be used, the plant may happen to adhere to the bottom of the still, get partially charred, and thus impart an empyreumatic odor to the product. But as the quality of water distilled depends less upon the quantity employed, than upon that of the surface exposed to the heat, [illegible] is obvious that by giving a suitable form to the still, we may get rid of every inconvenience. Hence the narrower and taller the alembic is, within certain limits, the greater will be the proportion of oil relative to that of the aromatic water, from like proportions of aqueous and vegetable matter employed. Some place the plants in baskets, and suspend these immediately over the bottom of the still under the water, or above its surface in the steam. But the best mode in my opinion is to stuff an upright cylinder full of the plants, and to drive down through them, steam of any desired force; its tension and temperature being further regulated by the size of the outlet orifice leading to the condenser. The cylinder should be made of strong copper tinned inside, and incased in the worst conducting species of wood, such as soft deal or sycamore.

The distillation is to be continued as long as the water comes over of a milky appearance. Certain plants yield so little oil by the ordinary processes, notwithstanding every care, that nothing but a distilled water is obtained. In this case, the same water must be poured upon a fresh quantity of the plants in the still; which being drawn over, is again to be poured upon fresh plants; and thus repeatedly, till a certain dose of oil be separated. This being taken off, the saturated water is reserved for a like distillation.

The refrigeratory.vessel is usually a worm or serpentine plunged in a tub of water, whose temperature should be generally cold; but for distilling the oils of anise-seed, fennel, &c., which become concrete at low temperatures, the water should not be cooler than 45° F.

The liquid product is commonly made to run at the worm end, into a vessel called an Italian or Florentine receiver, which is a conical matrass, standing on its base, with a pipe rising out of the side close to the bottom, and recurved a little above the middle of the flask like the spout of a coffee-pot. The water and the oil collected in this vessel soon separate from each other, according to their respective specific gravities; the one floating above the other. If the water be the denser, it occupies the under portion of the vessel, and continually overflows by the spout in communication with the bottom, while the lighter oil is left. When the oil is the heavier of the two, the receiver should be a large inverted cone, with a stopcock at its apex to run off the oil from the water when the separation has been completed by repose. A funnel, having a glass stopcock attached to its narrow stem, is the most convenient apparatus for freeing the oil finally from any adhering particles of water. A cotton wick dipped in the oil may also serve the same purpose by its capillary action. The less the oil is transvased the better, as a portion of it is lost at every transfer. It may occasionally be useful to cool the distilled water by surrounding it with ice, because it thus parts with more of the oil with which it is impregnated.

There are a few essential oils which may be obtained by expression, from the substances which contain them; such as the oils of lemons and bergamot, found in the pellicle of the ripe fruits of the *citrus aurantium* and *medica;* or the orange and the citron. The oil comes out in this case with the juice of the peel, and collects upon its surface.

For collecting the oils of odoriferous flowers which have no peculiar organs for imprisoning them, and therefore speedily let them exhale, such as violets, jasmine, tuberose, and hyacinth, another process must be resorted to. Alternate layers are formed of the fresh flowers, and thin cotton fleece or woollen cloth-wadding, previously soaked in a pure and inodorous fat oil. Whenever the flowers have given out all their volatile oil to the fixed oil upon the fibrous matter, they are replaced by fresh flowers in succession, till the fat oil has become saturated with the odorous particles. The cotton or wool wadding being next submitted to distillation along with water, gives up the volatile oil. Perfumers seldom use these oils; they employ them either mixed as above, or dissolve them out by means of alcohol. In order to extract the oils of certain flowers, as for instance of white lilies, infusion in a fat oil is sufficient.

Essential oils differ much from each other in their physical properties. Most of them are yellow, others are colorless, red, or brown; some again are green, and a few are blue. They have a powerful smell, more or less agreeable, which immediately after their distillation is occasionally a little rank, but becomes less so by keeping. The odor is seldom as pleasant as that of the recent plant. Their taste is acrid, irritating, and heating, or merely aromatic when they are largely diluted with water or other substances. They are not greasy to the touch, like the fat oils, but on the contrary make the skin feel rough. They are almost all lighter than water, only a very few falling to the bottom of this liquid; their specific gravity lies between 0·847 and 1·096; the first number denoting the density of oil of citron, and the second that of oil of sassafras. Although styled volatile oils, the tension of their vapor, as well as its specific heat, is much less than that of water. The boiling point differs in different kinds, but it is usually about 316° or 320° Fahr. Their vapors sometimes render reddened litmus paper blue, although they contain no ammonia. When distilled by themselves, the volatile oils are partially decomposed; and the gaseous products of the portion decomposed always carry off a little of the oil. When they are mixed with clay or sand, and exposed to a distilling heat, they are in a great measure decomposed; or when they are passed in vapor through a redhot tube, combustible gases are obtained, and a brilliant porous charcoal is deposited in the tube. On the other hand, they distil readily with water, because the aqueous vapor formed at the surface of the boiling fluid carries along with it the vapor of the oil produced in virtue of the tension which it possesses at the 212th degree Fahr. In the open air, the volatile oils burn with a shining flame, which deposites a great deal of soot. The congealing point of the essential oils varies greatly; some do not solidify till cooled below 32°, others at this point, and some are concrete at the ordinary temperature of the atmosphere. They comport themselves in this respect like the fat oils; and they probably consist, like them, of two different oils, a solid and a fluid; to which the names *stearoptène* and *eleoptène*, or stearessence and oleiessence, may be given. These may be separated from each other by compressing the cooled concrete oil between the folds of porous paper; the stearessence remains as a solid upon the paper; the oleiessence penetrates the paper, and may be recovered by distilling it along with water.

When exposed to the air, the volatile oils change their color, become darker, and gradually absorb oxygen. This absorption commences whenever they are extracted from the plant containing them; it is at first considerable, and diminishes in rapidity as it goes on. Light contributes powerfully to this action, during which the oil disengages a little carbonic acid, but much less than the oxygen absorbed; no water is formed. The oil turns gradually thicker, loses its smell, and is transformed into a resin, which becomes eventually hard. De Saussure found that oil of lavender, recently distilled, had absorbed in four winter months, and at a temperature below 54° F., 52 times its volume of oxygen, and had disengaged twice its volume of carbonic acid gases; nor was it yet completely saturated with oxygen. The stearessence of anise-seed oil absorbed at its liquefying temperature, in the space of two years, 156 times its volume of oxygen gas, and disengaged 26 times its volume of carbonic acid gas. An oil which has begun to experience such an oxydizement is composed of a resin dissolved in the unaltered oil; and the oil may be separated by distilling the solution along with water. To preserve oils in an unchanged state, they must be put in vials, filled to the top, closed with ground glass stopples, and placed in the dark.

Volatile oils are little soluble in water, yet enough so as to impart to it by agitation their characteristic smell and taste. The water which distils with any oil is in general a saturated solution of it, and as such is used in medicine under the name of distilled water. It often contains other volatile substances contained in the plants, and hence is apt to putrefy and acquire a nauseous smell when kept in perfectly corked bottles; but in vessels partially open, these parts exhale, and the water remains sweet. The waters, however, which are made by agitating volatile oil with simple distilled water, are not apt to spoil by keeping in well-corked bottles.

The volatile oils are soluble in alcohol, and the more so the stronger the spirit is. Some volatile oils, devoid of oxygen, such as the oils of turpentine and citron, are very sparingly soluble in dilute alcohol; while the oils of lavender, pepper, &c. are considerably so. De Saussure has inferred from his experiments that the volatile oils are the more soluble in alcohol, the more oxygen they contain. Such combinations form the odoriferous spirits which the perfumers incorrectly call waters, as *lavender water*, *eau de Cologne*, *eau de jasmin*, &c. They become turbid by admixture of water, which seizes the alcohol, and separates the volatile oils. Ether also dissolves all the essential oils.

These oils combine with several vegetable acids, such as the acetic, the oxalic, the succinic, the fat acids (stearic, margaric, oleic), the camphoric, and suberic.

With the exception of the oil of cloves, the volatile oils do not combine with the salifiable bases. They have been partially combined with caustic alkali, as in the case of Starkey's soap. This is prepared by triturating recently fused caustic soda in a mortar, with a little oil of turpentine, added drop by drop, till the mixture has acquired the consistence of soap. The compound is to be dissolved in spirits of wine, filtered, and distilled. What remains after the spirit is drawn off, consists of soda combined with a resin formed in the oil during the act of trituration.

The volatile oils in general absorb six or eight times their bulk of ammoniacal gas; but that of lavender absorbs 47 times.

The essential oils dissolve all the fat oils, the resins, and the animal fats.

In commerce these oils are often adulterated with fat oils, resins, or balsam of capivi dissolved in volatile oil. This fraud may be detected by putting a drop of the oil on paper, and exposing it to heat. A pure essential oil evaporates without leaving any residuum, whilst an oil mixed with any of the above substances leaves a translucent stain upon the paper. If fat oil be present, it will remain undissolved, on mixing the adulterated essential oil with thrice its volume of spirit of wine of specific gravity 0·840. Resinous matter mixed with volatile oil is easily detected, being left in the alembic after distillation. Oil diluted with spirit of wine, forms a milky emulsion on the addition of water; the alcoholic part is absorbed by the water, and the oil afterwards found on the surface, in a graduated glass tube, will show by its quantity the amount of the adulteration.

But it is more difficult to detect the presence of a cheap essential oil in a dear one, which it resembles. Here the taste and smell are our principal guides. A few drops of the suspected oil are to be poured upon a bit of cloth, which is to be shaken in the air, and smelled to from time to time. In this way we may succeed in distinguishing the odor of the oil which exhales at the beginning, and that which exhales at the end; a method which serves perfectly to detect oil of turpentine in the finer essential oils. Moreover, when the debased oil is mixed with spirits of wine at sp. gr. 0·840, the oil of turpentine remains in a great measure undissolved. If an oil heavier than water, and an oil lighter than water, be mixed, they may be separated by agitation for some time with that liquid, and then leaving the mixture at rest. Essential oils may also be distinguished by a careful examination of their respective densities.

Oil of bitter almonds is prepared by exposing the bitter almond cake, from which the bland oil has been expressed, in a sieve to the vapor of water rising within the still. The steam, as it passes up through the bruised almond *parenchyma*, carries off its volatile oil, and condenses along with it in the worm. The oil which first comes over, and which falls to the bottom of the water, has so pungent and penetrating a smell, that it is more like cyanogen gas than hydrocyanic or prussic acid. This oil has a golden yellow color, it is heavier than water; when much diluted, it has an agreeable smell, and a bitter burning taste. When exposed to the air, it absorbs oxygen, and lets fall a heap of crystals of benzoic acid. This oil consists of a mixture of two oils; one of which is volatile, contains hydrocyanic acid, and is poisonous; the other is less volatile, is not poisonous, absorbs oxygen, and becomes benzoic acid. If we dissolve 100 parts of the oil of bitter almonds in spirit of wine, mix with the solution an alcoholic solution of potash, and then precipitate the oil with water, we shall obtain a quantity of cyanide of potash, capable of producing 22½ parts of Prussian blue. Oil of bitter almonds combines with the alkalis. Perfumers employ a great quantity of this oil in scenting their soaps. One manufacturer in Paris is said to prepare annually 3 cwts. of this oil. A similar poisonous oil is obtained by distilling the following substances with water:—the leaves of the peach (*amygdalus persica*), the leaves of the bay-laurel (*prunus lauro-cerasus*), the bark of the plum-tree (*prunus padus*), and the bruised kernels of cherry and plumstones. All these oils contain hydrocyanic acid, which renders them poisonous, and they also generate benzoic acid, by absorbing oxygen on exposure to air.

Oil of anise-seed is extracted by distillation from the seeds of the *pimpinella anisum.* It is either colorless, or has merely a faint yellow color, with the smell and taste of the seed. It concretes in lamellar crystals at the temperature of 50°, and does not melt again till heated to 64° nearly. Its specific gravity at 61° is 0·9958, and at 77°, 0·9857. It is soluble in all proportions in alcohol of 0·806; but only to the extent of 42 per cent. in alcohol of 0·84. When it becomes resinous by long exposure to the air, it loses its congealing property. It consists of two oils; a solid stearessence, and a liquid oleiessence, which may be separated by compression of the cold concrete oil.

Oil of bergamot is extracted by pressure from the rind of the ripe fruit of the *citrus bergamium* and *aurantium.* It is a limpid, yellowish fluid, having a smell resembling that of oranges. Its specific gravity varies from 0·888 to 0·885. It becomes concrete when cooled a little below 32°.

Oil of cajeput is prepared in the Moluccas, by distilling the dry leaves of the *melaleuca leucadendron.* Cajeput is a native word, signifying merely a white tree. This oil is green; it has a burning taste, a strong smell of camphor, turpentine, and savine. It is very fluid, and at 48° has a specific gravity of 0·948. The color seems to be derived from the copper vessels in which it is imported, so that it is removed by distillation with water, which also separates the oil into two sorts; the first which comes over having a density of 0·897, the last of 0·920. This has a green color.

The oil of caraway is extracted from the seeds of the *carum carui.* It has a pale yellow color, and the smell and taste of the plant. Its specific gravity is 0·960. The seeds of the *cuminum cyminum* (cumin) afford an oil similar to the preceding, but not so agreeable. Its specific gravity is 0·975.

The oil of cassia, from the *laurus cassia*, is yellow passing into brown, has a specific gravity of 1·071, and affords a crystalline stearessence by keeping in a somewhat open vessel.

The oil of chamomile is extracted by distillation from the flowers of the *matricaria chamomilla.* It has a deep blue color, is almost opaque, and thick; and possesses the peculiar smell of the plant. In the atmosphere it becomes brown and unctuous. If an ounce of oil of lemons be added to 3 pounds of this oil, they make it separate more readily from the adhering water.

Other blue oils, having much analogy with oil of chamomile, are obtained by distilling the following plants: Roman chamomile (*anthemis nobilis*), the flowers of *arnica montana*, and those of milfoil (*achillæa millefolia*). The last has a spec. grav. of 0·852.

Oil of cinnamon is extracted by distillation from the bark of the *laurus cinnamomum*. It is produced chiefly in Ceylon, from the pieces of bark unfit for exportation. It is distilled over with difficulty, and the process is promoted by the addition of salt water, and the use of a low still. It has at first a pale yellow color, but it becomes brown with age. It possesses in a high degree both the sweet burning taste, and the agreeable smell of cinnamon. It is heavier than water; its specific gravity being 1·035. It concretes below 32° F., and does not fuse again till heated to 41°. It is very sparingly soluble in water, and when agitated with it readily separates by repose. It dissolves abundantly in alcohol, and combines with ammonia into a viscid mass, not decomposed on exposure to air.

When oil of cinnamon is kept for a long time, it deposites a stearessence in large regular colorless or yellow crystals, which may be pulverized, and which melt at a very gentle heat into a colorless liquid, which crystallizes on cooling. It has an odor intermediate between that of cinnamon and vanilla; and a taste at first greasy, but afterwards burning and aromatic. It crackles between the teeth. It requires a high temperature for distillation, and becomes then brown and empyreumatic. It is very soluble in alcohol.

The oil of cloves is extracted from the dried flower buds of the *caryophyllus aromaticus*. It is colorless, or yellowish, has a strong smell of the cloves, and a burning taste. Its specific gravity is 1·061. It is one of the least volatile oils, and the most difficult to distil. At the end of a certain time it deposites a crystalline concrete oil. A similar *stearessence* is obtained by boiling the bruised cloves in alcohol, and letting the solution cool. The crystals thus formed are brilliant, white, grouped in globules, without taste and smell. Oil of cloves has remarkable chemical properties. It dissolves in alcohol, ether, and acetic acid. It does not solidify at a temperature of 4° under 0° F., even when exposed to that cold for several hours. It absorbs chlorine gas, becomes green, then brown, and turns resinous. Nitric acid makes it red, and if heated upon it, converts it into oxalic acid. If mixed by slow degrees with one third of its weight of sulphuric acid, an acid liquor is formed, at whose bottom a resin of a fine purple color is found. After being washed, this resin becomes hard and brittle. Alcohol dissolves it, and takes a red color; and water precipitates it of a blood red hue. It dissolves also in ether. When we agitate a mixture of strong caustic soda ley and oil of cloves in equal parts, the mass thickens very soon, and forms delicate lamellar crystals. If we then pour water upon it, and distil, there passes along with the water, a small quantity of an oil which differs from oil of cloves both in taste and chemical properties. During the cooling, the liquor left in the retort lets fall a quantity of crystalline needles, which being separated by expression from the alkaline liquid, are almost inodorous, but possess an alkaline taste, joined to the burning taste of the oil. These crystals require for solution from 10 to 12 parts of cold water. Potash ley produces similar effects. Ammoniacal gas transmitted through the oil is absorbed and makes it thick. The concrete combination thus formed remains solid as long as the vial containing it is corked, but when opened, the compound becomes liquid; and these phenomena may be reproduced as many times as we please. Such combinations are decomposed by acids, and the oil set at liberty has the same taste and smell as at first, but it has a deep red color. The alkalis enable us to detect the presence of other oils, as that of turpentine or sassafras, in that of cloves, because they fix the latter, while the former may be volatilized with water by distilling the mixture. The oil of cloves found in commerce is not pure, but contains a mixture of the tincture of pinks or clove-gillyflowers, whose acrid resin is thereby introduced. It is sometimes sophisticated with other oils.

The oil of elder is extracted by distillation from the flowers of the *sambucus nigra*. It has the consistence of butter. The watery solution is used in medicine.

Oil of fennel is extracted by distillation from the seeds of the *anethum fœniculum*. It is either colorless or of a yellow tint, has the smell of the plant, and a specific gravity of 0·997. When treated with nitric acid, it affords benzoin. It congeals at the temperature of 14° F., and then yields by pressure a solid and a liquid oil; the former appearing in crystalline plates. It is used in this country for scenting soap.

Oils of fermented liquors. The substances usually fermented contain a small quantity of essential oils, which become volatile along with the alcoholic vapors in distillation, and progressively increase as the spirits become weaker towards the end of the process. The vapors then condense into a milky liquor. These oils adhere strongly to the alcohol, and give it a peculiar acrid taste. They differ according to the vinous wash from which they are obtained, and combine with greater or less facility with caustic alkalis.

1. *Oil of grain spirits.* At the ordinary temperature it is partially a white solid; when cooled lower it assumes the aspect of suet, and therefore consists chiefly of stearessence. Its taste and smell are most offensive; it swims upon the surface of water, and even of spirit containing 30 per cent. of alcohol. It sometimes derives a green color from the copper worm of the still. When heated it fuses and turns yellow. When it has become resinous by the agency of the atmosphere, it gives a greasy stain to paper. It dissolves in 6 parts of anhydrous alcohol, and in two of ether; and is said to crystallize when the spirit solution has been saturated with it hot, and is allowed to cool. By exposure to a freezing mixture, the whiskey which contains it lets it fall. Caustic potash dissolves it very slowly, and forms a soap soluble in 60 parts of water. It is absorbed by wood charcoal, and still better by bone black; whereby it may be completely abstracted from bad whiskey. According to Buchner, another oil may also be obtained from the residuum of the second distillation of whiskey, if saturated with sea salt, and again distilled. Thus we obtain a pale yellow fluid oil, which does not concrete with cold, possessed of a disagreeable smell and acrid taste. Its specific gravity is 0·835. It is soluble in alcohol and ether.

2. *The oil from potato spirits* has properties quite different from the preceding. It is obtained in considerable quantity by continuing the distillation after most of the alcohol has come over, and it appears in the form of a yellowish oil, mixed with water and spirits. After being agitated first with water, then with a strong solution of muriate of lime, and distilled afresh, it possesses the following properties; it is colorless, limpid, has a peculiar smell, and a bitter hot taste of considerable permanence. It leaves no greasy stain upon paper, remains liquid at 0° F., but cooled below that point it crystallizes like oil of anise-seed. When pure it boils at 257° F.; but at a lower degree, if it contains alcohol. Its specific gravity is 0·821, or 0·823 when it contains a little water. It burns with a clear flame without smoke, but it easily goes out, if not burned with a wick. It dissolves in small quantity in water, to which it imparts its taste and the properties of forming a lather by agitation. It dissolves in all proportions in alcohol. Chlorine renders it green. Concentrated sulphuric acid converts it into a crimson solution, from which it is precipitated yellow by water. It dissolves in all proportions in acetic acid. Concentrated caustic leys dissolve it, but give it up to water. It does not appear to be poisonous, like the oil of corn spirits; because, when given by spoonfuls to dogs, it produced no other effect but vomiting.

3. *The oil of brandy or grape spirits* is obtained during the distillation of the fermented residuum of expressed grapes; being produced immediately after the spirituous liquor has passed over. It is very fluid, limpid, of a penetrating odor, and an acrid disagreeable taste. It grows soon yellow in the air. When this oil is distilled, the first portions of it pass unchanged, but afterwards it is decomposed and becomes empyreumatic. It dissolves in 1000 parts of water, and communicates to it its peculiar taste and smell. One drop of it is capable of giving a disagreeable flavor to ten old English gallons of spirits. It combines with the caustic alkalis, and dissolves sulphur.

Oil of juniper is obtained by distilling juniper berries along with water. These should be bruised, because their oil is contained in small sacs or reservoirs, which must be laid open before the oil can escape. It is limpid and colorless, or sometimes of a faint greenish yellow color. Its specific gravity is 0·911. It has the smell and taste of the juniper. Water, or even alcohol, dissolves very little of it. Gin contains a very minute quantity of this oil. Like oil of turpentine, it imparts to the urine of persons who swallow it, the smell of violets. Oil of juniper is frequently sophisticated with oil of turpentine introduced into the still with the berries; a fraud easily detected by the diminished density of the mixture.

The oil of lavender is extracted from the flowering spike of the *lavandula spica.* It is yellow, very fluid, has a strong odor of the lavender, and a burning taste. The specific gravity of the oil found in commerce is 0·898 at the temperature of 72° F., and of 0·877 when it has been rectified. It is soluble in all proportions in alcohol of 0·830, but alcohol of 0·887 dissolves only 42 per cent. of its weight. The fresh oil detonates slightly when mixed with iodine, with the production of a yellow cloud. There occurs in commerce a kind of oil of lavender known under the name of oil of *aspic* or oil of *spike,* extracted by distillation from a wild variety of the *lavandula spica,* which has large leaves, and is therefore called *latifolia.* This oil is manufactured in the south of Europe. Its odor is less characteristic than that of the lavender, resembling somewhat that of oil of turpentine, with which it is indeed often adulterated. It is also so cheap as to be sometimes used instead of the latter oil. Oil of lavender deposites, when partially exposed to the air, a concrete oil, which resembles camphor, to the amount of one fourth of its weight.

Oil of lemons is extracted by pressure from the yellow peel of the fruit of the lemon, or *citrus medica.* In this state it is a yellowish fluid, having a specific gravity of 0·8517; but when distilled along with water till three fifths of the oil have come over, it is obtained in a colorless state, and of a specific gravity of 0·847 at 72° F. This oil does not become concrete till cooled to 4° below 0° F.

The oil of lemons has a very agreeable smell of the fruit, which is injured by distillation. It is soluble in all proportions in anhydrous alcohol, but only 14 parts dissolve in 100 of spirits of wine of specific gravity 0·837. This oil, especially when distilled, forms with muriatic acid similar camphorated compounds with oil of turpentine, absorbing no less than 280 volumes of the acid gas.

Oil of lemons kept long, in ill-corked bottles, generates a quantity of stearessence, which when dissolved in alcohol, precipitated by water, and evaporated, affords brilliant, colorless, transparent needles. Some acetic acid is also generated in the old oil. According to Brandes, the specific gravity of oil of lemons is 0·8786.

The oil of mace lets fall, after a certain time, a concrete oil under the form of a crystalline crust, called by John *myristicine.*

The oil of nutmegs is extracted chiefly from mace, which is the inner epidermis of these nuts. It is colorless, or yellowish, a little viscid with a strong aromatic odor of nutmegs, an acrid taste, and a specific gravity of 0·948. It consists of two oils, which may be easily separated from each other by agitation with water; for one of them, which is more volatile and aromatic, comes to the surface, while the other, which is denser, white, and of a buttery consistence, falls to the bottom. The latter liquefies by the heat of the hand.

The oil of orange flowers, called *neroli,* is extracted from the fresh flowers of the *citrus aurantium.* When recently prepared it is yellow; but when exposed for two hours to the rays of the sun, or for a longer time to diffuse daylight, it becomes of a yellowish-red. It is very fluid, lighter than water, and has a most agreeable smell. The aqueous solution known under the name of orange-flower water, is used as a perfume. It is obtained either by dissolving the oil in water, or by distilling with water the leaves either fresh or salted; the first being the stronger, but the last being the more fragrant preparation. Orange-flower water obtained by distillation, contains besides the oil, a principle which comes over with it, of a nature hitherto unknown; it possesses the property of imparting to water the faculty of becoming red with a few drops of sulphuric acid. The water formed from the oil alone, is destitute of this property. The intensity of the rose-color is a test in some measure of the richness of the water in oil.

The oil of parsley is extracted from the *apium petroselinum.* It is of a pale yellow color, having the smell of the plant, and consists of two oils separable by agitation in water. Its liquid part floats upon the surface in a very fluid form; its stearessence, which falls to the bottom, is butyraceous and crystallizes at a low temperature. This concrete oil melts at 86° F.

The oil of pepper is extracted from the *piper nigrum.* In the recent state it is limpid and colorless, but by keeping it becomes yellow. It swims upon the surface of water. In odor it resembles pepper, but is devoid of its hot taste.

The oil of peppermint is extracted from the *mentha piperita.* It is yellowish, and endued with a very acrid burning taste. Its specific gravity is 0·920. At 6° or 7° below 0° F., it deposites small capillary crystals. After long keeping it affords a stearessence resembling camphor, provided the oil had been obtained from the dry plant gathered in flower, but not from distillation of the fresh plant. When artificially cooled, it yields 6 per cent. of stearessence, which crystallizes in prisms with three sides, has an acrid, somewhat rank taste, is soluble in ether and alcohol, and is thrown down from the latter solution by water in the form of a white powder. Peppermint water is characterized by the sensation of coolness which it diffuses in the mouth.

The oil of pimento is extracted from the envelopes of the fruits of the *myrtus pimenta,* which afford 8 per cent. of it. It is yellowish, almost colorless, of a smell analogous to that of cloves, an acrid burning taste, and a specific gravity greater than water. Nitric acid makes it first red, and after the effervescence, of a rusty brown hue. It combines with the salifiable bases, like oil of cloves.

The oil of rhodium is extracted from the wood of the *convolvolus scoparius.* It is very fluid, and has a yellow color, which in time becomes red. It has somewhat of the rose odor, and is used to adulterate the genuine *otto.* Its taste is bitter and aromatic, which it imparts to the otto as well as its fluidity.

The oil of roses, called also the *attar* or *otto,* is extracted by distillation from the petals of the *rosa centifolia* and *sempervirens.* Our native roses furnish such small quantities of the oil, that they are not worth distilling for the purpose. The best way of operating is to return the distilled water repeatedly upon fresh petals, and eventually to cool the saturated water with ice; whereby a little butyraceous oil is deposited. But the oil thus obtained has not a very agreeable odor, being injured by the action of the air in the repeated distillations. In the East Indies, the attar is obtained by stratifying rose leaves in earthen pans in alternate layers, with the oleiferous seeds of a species of digitalis, called *gengeli*, for several days, in a cool situation. The fat oil of the seed absorbs the essential oil of the rose. By repeating this process with fresh leaves and the same seed. this becomes eventually swollen, and being then expressed furnishes the oil. The turbid liquid thus obtained is left at rest, in well-closed vessels, where it gets clarified. The layer of oil that floats on the top is then drawn off by a capillary cotton wick, and subjected to distillation along with water, whereby the volatile otto is separated from the fat seed-oil.

The oil of roses is colorless, and possesses the smell of roses, which is not however agreeable, unless when diffused, for in its concentrated state it is far from pleasant to the nostrils, and is apt to occasion headaches. Its taste is bland and sweetish. It is lighter than water, and at the temperature of 92°, its specific gravity compared to that of water at 60° is 0·832. At lower temperatures it becomes concrete and butyraceous; and afterwards fuses at 90°. It is but slightly soluble in alcohol; 1000 parts of this liquid at 0·806 dissolving only 7½ parts at 58° F. This oil consists of two parts, the stearessence and oleiessence; the latter being the more volatile odoriferous portion.

The oil of rosemary is extracted from the *rosmarinus officialis*. It is as limpid as water, has the smell of the plant, and in other respects resembles oil of turpentine. The oil found in commerce has a specific gravity of 0·911, which becomes 0·8886 by rectification. It boils at 320° F. (occasionally at 329°). It is soluble in all portions in alcohol of 0 830. When kept in imperfectly closed vessels, it deposites a stearessence to the amount of one tenth of its weight, resembling camphor. It is sometimes adulterated with oil of turpentine, a fraud easily detected by adding anhydrous alcohol, which dissolves only the oil of rosemary.

The oil of saffron is extracted from the *stigmata* of the *crocus sativus*. It is yellow, very fluid, falls to the bottom of water, diffuses the penetrating odor of the plant, and has an acrid and bitter taste. It is narcotic.

The oil of sassafras is extracted from the woody root of the *laurus sassafras*. It is colorless, but at the end of a certain time it becomes yellow or red. It has a peculiar, sweetish, pretty agreeable, but somewhat burning taste. Its specific gravity is 1·094. According to Bonastre, this oil separates by agitation with water into an oil lighter and an oil heavier than this fluid. When long kept, it deposites a stearessence in transparent and colorless crystals, which have the smell and taste of the liquid oil.

The oil of savine is extracted from the leaves of the *juniperus sabina*. It is limpid, and has the odor and taste of the plant, which is one more productive of volatile oil than any other.

The oil of tansy has a specific gravity of 0·946, the penetrating odor of the *tanacetum vulgare*, with an acrid and bitter taste.

Oil of turpentine, commonly called essence of turpentine. It is extracted from several species of turpentine, a semi-liquid resinous substance which exudes from certain trees of the *pine* tribe, and is obtained by distilling the resin along with water. This oil is the cheapest of all the volatile species, and, as commonly sold, contains a little resin, from which it may be freed by re-distillation with water. It is colorless, limpid, very fluid, and has a very peculiar smell. Its specific gravity at 60° is 0·872; that of the spirit on sale in the shops is 0·876. This oil always reddens litmus paper, because it contains a little succinic acid.

100 parts of spirits of wine, of specific gravity 0·84, dissolve only 13½ of oil of turpentine at 72° F. When agitated with alcohol at 0·830 the oil retains afterwards one fifth of its bulk of the spirit; hence this proposed method for purifying oil of turpentine is defective. The oil, if left during four months in contact with air, is capable of absorbing 20 times its bulk of oxygen gas. One volume of rectified oil of turpentine absorbs at the temperature of 72°, and under the common atmospheric pressure, 163 times its volume of muriatic acid gas, provided the vessel be kept cool with ice. This mixture being allowed to repose for 24 hours, produces out of the oil from 26 to 47 per cent. of a white crystalline substance, which subsides to the bottom of a brown, smoking, translucent liquor. Others say that 100 parts of oil of turpentine yield 110 of this crystalline matter, which was called by Kind, its discoverer, artificial camphor, from its resemblance in smell and appearance to this substance. Both the solid and the liquid are combinations of muriatic acid and oil of turpentine; indicating the existence of a stearine and an oleine in the latter substance. The liquid compound is lighter than water, and is not decomposed by it, nor does it furnish any more solid matter when more muriatic gas is passed through it. The solid compound, after being washed first with water containing a little carbonate of soda, then with pure water, and finally purified by sublimation with some chalk, lime, ashes, or charcoal, appears as a white, translucent, crystalline body, in the form of flexible, tenacious needles. It swims upon the surface of water, diffuses a faint smell of camphor, commonly mixed with that of oil of turpentine, and has rather an aromatic than a camphorated taste. It does not redden litmus paper. Water

dissolves a very minute quantity; but cold alcohol of 0·806 dissolves fully one third of its weight, and hot much more, depositing, as it cools, this excess in the form of crystals. The solution is not precipitated by nitrate of silver, which shows that the nature of the muriatic acid is perfectly masked by the combination. It is composed, in 100 parts, of 76·4 carbon, 9·6 hydrogen, and 14 muriatic acid. The muriatic acid, or chlorine, may be separated by distilling an alcoholic solution of the artificial camphor 12 or 14 times in succession with slaked lime.

Oil of turpentine is best preserved in casks enclosed within others, with water between the two. Its principal use is for making varnishes, and as a remedy for the tape-worm.

The oil of thyme is extracted from the *thymus serpyllum.* It is reddish yellow, has an agreeable smell, and, after being long kept, it lets fall a crystalline stearessence. It is used merely as a perfume.

The oil of wormwood is extracted from the *artemisia absinthium.* It is yellow, or sometimes green, and possesses the odor of the plant. Its taste resembles that of wormwood, but without its bitterness. Its specific gravity is 0·9703, according to Brisson, and 0·9725, according to Brandes. It detonates with iodine when it is fresh. Treated with nitric acid of 1·25 specific gravity, it becomes first blue, and after some time brown.

OIL OF VITRIOL is the old name of concentrated Sulphuric Acid.

OLEATES are saline compounds of oleic acid with the bases.

OLEFIANT GAS is the name originally given to bi-carbureted hydrogen.

OLEIC ACID is the acid produced by saponifying olive oil, and then separating the base by dilute sulphuric or muriatic acid. See Fats, and Stearine.

OLEINE is the thin oily part of fats, naturally associated in them with glycerine, margarine, and stearine.

OLIBANUM is a gum-resin, used only as incense in Roman Catholic churches.

OLIVE OIL. See Oils, unctuous.

ONYX, an ornamental stone of little value; a subspecies of quartz.

OOLITE is a species of limestone composed of globules clustered together, commonly without any visible cement or base. These vary in size from that of small pin-heads to peas; they sometimes occur in concentric layers; at others they are compact, or radiated from the centre to the circumference; in which case, the oolite is called *roogenstein* by the German mineralogists. In geology the oolitic series includes all the strata between the iron sand above and the red marl below. It is the great repository of the best architectural materials which the midland and eastern parts of England produce; it is divided into three systems:—

1. *The upper oolite,* including the argillo-calcareous Purbeck strata, which separate the iron and oolitic series; the oolitic strata of Portland, Tisbury, and Aylesbury; the calcareous sand and concretions, as of Shotover and Thame; and the argillo-calcareous formation of Kimmeridge, the oak tree of Smith.

2. *The middle oolite;* the oolitic strata associated with the coral rag; calcareous sand and grit; great Oxford clay, between the oolites of this and the following system.

3. *The lower oolite;* which contains numerous oolitic strata, occasionally subdivided by thin argillaceous beds; including the cornbrash, forest marble, schistose oolite, and sand of Stonesfield and Hinton, great oolite and inferior oolite; calcareo-silicious sand passing into the inferior oolite; great argillo-calcareous formation of lias, and lias marl, constituting the base of the whole series.

These formations occupy a zone 30 miles broad in England.

OOST, or OAST; the trivial or provincial name of the stove in which the picked hops are dried.

OPAL; an ornamental stone of moderate value. See Lapidary.

OPERAMETER is the name given to an apparatus patented in February, 1829, by Samuel Walker, cloth manufacturer, in the parish of Leeds. It consists of a train of toothed wheels and pinions enclosed in a box, having indexes attached to the central arbor, like the hands of a clock, and a dial plate; whereby the number of rotations of a shaft projecting from the posterior part of the box is shown. If this shaft be connected by any convenient means to the working parts of a gig mill, shearing frame, or any other machinery of that kind for dressing cloths, the number of rotations made by the operating machine will be exhibited by the indexes upon the dial plate of this apparatus. In dressing cloths, it is often found that too little or too much work has been expended upon them, in consequence of the unskilfulness or inattention of the workmen. By the use of the operameter, that evil will be avoided, as the master may regulate and prescribe beforehand by the dial the number of turns which the wheels should perform.

A similar clock-work mechanism, called a *counter,* has been for a great many years employed in the cotton factories to indicate the number of revolutions of the main shaft of the mill, and of course the quantity of yarn that might or should be spun, or of cloth that might be woven in the power looms. A common pendulum or spring clock is commonly set up alongside of the counter; and sometimes the indexes of both are regulated to go together, when the mill performs its average work.

OPIUM, is the juice which exudes from incisions made in the heads of ripe poppies, (*papaver somniferum*,) rendered concrete by exposure to the air and the sun. The best opium which is found in the European markets comes from Asia Minor and Egypt; what is imported from India is reckoned inferior in quality. This is the most valuable of all the vegetable products of the gum-resin family: and very remarkable for the complexity of its chemical composition. Though examined by many able analysts, it still requires farther elucidation.

Opium occurs in brown lumps of a rounded form about the size of the fist, and often larger; having their surface covered with the seeds and leaves of a species of *rumex*, for the purpose of preventing the mutual adhesion of the pieces in their semi-indurated state. These seeds are sometimes introduced into the interior of the masses to increase their weight; a fraud easily detected by cutting them across. Good opium is hard in the cold, but becomes flexible and doughy when it is worked between the hot hands. It has a characteristic smell, which by heat becomes stronger, and very offensive to the nostrils of many persons. It has a very bitter taste. Water first softens, and then reduces it to a pasty magma. Proof spirit digested upon opium forms *laudanum*, being a better solution of its active parts than can be obtained by either water or strong alcohol alone. Water distilled from it acquires its peculiar smell, but carries over no volatile oil.

Opium was analyzed by Bucholz and Braconnot, but at a period anterior to the knowledge of the alkaline properties of morphia and opian (narcotine). Bucholz found in 100 parts of it, 9·0 of resin; 30·4 of gum; 35·6 of extractive matter; 4·8 of caoutchouc; 11·4 of gluten; 2·0 of ligneous matter, as seeds, leaves, &c.; 6·8 of water and loss. John, who made his analysis more recently, obtained 2·0 parts of a rancid nauseous fat; 12·0 of a brown hard resin; 10·0 of a soft resin; 2 of an elastic substance; 12·0 of morphia and opian; 1·0 of a balsamic extract; 25·0 of extractive matter; 2·5 of the meconates of lime and magnesia; 18·5 of the epidermis of the heads of the poppy; 16 of water, salts, and odorous matter.

In the Numbers of the Quarterly Journal of Science for January and June, 1830, I published two papers upon opium and its tests, containing the results of researches made upon some porter which had been fatally dosed with that drug; for which crime, a man and his wife had been capitally punished, about a year before, in Scotland.* From the first of these papers the following extract is made:—

"Did the anodyne and soporific virtue of opium reside in one definite principle, chemical analysis might furnish a certain criterion of its powers. It has been pretty generally supposed that this desideratum is supplied by Sertürner's discovery of morphia. Of this narcotic alkali not more than 7 parts can be extracted by the most rigid analysis from 100 of the best Turkey opium; a quantity, indeed, somewhat above the average result of many skilful chemists. Were morphia the real medicinal essence of the poppy, it should display, when administered in its active saline state of acetate, an operation on the living system commensurate in energy with the fourteen-fold concentration which the opium has undergone. But so far as may be judged from the most authentic recent trials, morphia in the acetate seems to be little, if any, stronger as a narcotic than the heterogeneous drug from which it has been eliminated. Mr. John Murray's experiments would, in fact, prove it to be greatly weaker; for he gave 2 drachms of superacetate of morphia to a cat, without causing any poisonous disorder. This is perhaps an extreme case, and may seem to indicate either some defect in the preparation, or an uncommon tenacity of life in the animal. To the same effect Lassaigne found that a dog lived 12 hours after 36 grains of acetate of morphia in watery solution had been injected into its jugular vein. The morphia meanwhile was entirely decomposed by the vital forces, for none of it could be detected in the blood drawn from the animal at the end of that period. Now, from the effects produced by 5 grains of watery extract of opium, injected by Orfila into the veins of a dog, we may conclude that a quantity of it, equivalent to the above dose of the acetate of morphia, would have proved speedily fatal.

"Neither can we ascribe the energy of opium to the white crystalline substance called *narcotine*, or *opian*, extracted from it by the solvent agency of sulphuric ether; for Orfila assures us that these crystals may be swallowed in various forms by man, even to the amount of 2 drachms in the course of 12 hours, with impunity; and that a drachm of it dissolved in muriatic or nitric acid may be administered in the food of a dog without producing any inconvenience to the animal. It appears, however, on the same authority, that 30 grains of it dissolved in acetic or sulphuric acid caused dogs that had swallowed the dose to die under convulsions in the space of 24 hours, while the head was thrown backwards on the spine. Oil seems to be the most potent menstruum of narcotine; for 3 grains dissolved in oil readily kill a dog, whether the dose be introduced into the stomach or into the jugular vein.

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* A country merchant travelling in a steam-boat upon the river Clyde, who had incautiously displayed a good deal of money, was poisoned with porter charged with laudanum. The contents of the dead man's stomach were sent to me for analysis.

"Since a bland oil thus seems to develop the peculiar force of narcotine, and since opium affords to ether, and also to ammonia, an unctuous or fatty matter, and a resin (the caoutchouc of Bucholz) to absolute alcohol, we are entitled to infer that the activity of opium is due to its state of composition, to the union of an oleate or margarate of narcotine with morphia. The meconic acid associated with this salifiable base has no narcotic power by itself, but may probably promote the activity of the morphia."

Opian or narcotine, and morphia, may be well prepared by the following process. The watery infusion of opium being evaporated to the consistence of an extract, every 3 parts are to be diluted with one and a half parts in bulk of water, and then mixed in a retort with 20 parts of ether. As soon as 5 parts of the ether have been distilled over, the narcotic salt contained in the extract will be dissolved. The fluid contents of the retort are to be poured hot into a vessel apart, and the residuum being washed with 5 other parts of ether, they are to be added to the former. Crystals of narcotine will be obtained as the solution cools. The remaining extract is to be diluted in the retort with a little water, and the mixture set aside in a cool place. After some time, some narcotine will be found crystallized at the bottom. The supernatant liquid thus freed from narcotine being decanted off, is to be treated with caustic ammonia; and the precipitate thrown upon a filter. This, when well washed and dried, is to be boiled with a quantity of spirit of wine at 0·84, equal to thrice the weight of the opium employed, containing 6 parts of animal charcoal for every hundred parts of the drug. The alcoholic solution being filtered hot, affords, on cooling, colorless crystals of morphia.

This alkali may be obtained by a more direct process without alcohol or ether. A solution of opium in vinegar, is to be precipitated by ammonia; the washed precipitate is to be dissolved in dilute muriatic acid, the solution is to be boiled along with powdered bone black, filtered, and then precipitated by ammonia. This, when washed upon a filter and dried, is white morphia, which may be dissolved in hot alcohol, if fine crystals be wanted. See MORPHIA.

Opium, quantity of,

	Imported.	Retained for consumption.	Exported.
Year.	*Lbs.*	*Lbs.*	*Lbs.*
1835.	85,481	31,181	74,126
1836.	130,794	38,943	70,824

Duty, at present, 1*s*. per lb.

OPOBALSAM is the balsam of Peru in a dry state.

OPOPONAX is a gum-resin resembling gum ammoniac. It is occasionally used in medicine.

ORANGE DYE is given by a mixture of red and yellow dyes in various proportions. Annotto alone dyes orange; but it is a fugitive color.

ORCINE is the name of the coloring principle of the *lichen dealbatus*. The lichen dried and pulverized is to be exhausted by boiling alcohol. The solution filtered hot, lets fall in the cooling crystalline flocks, which do not belong to the coloring matter. The supernatant alcohol is to be distilled off, the residuum is to be evaporated to the consistence of an extract, and triturated with water till this liquid will dissolve no more. The aqueous solution reduced to the consistence of sirup, and left to itself in a cool place, lets fall, at the end of a few days, long brown brittle needles, which are to be freed by pressure from the mother water, and dried. That water being treated with animal charcoal, filtered and evaporated, will yield a second crop of crystals. These are orcine. Its taste is sweet and nauseous; it melts readily in a retort into a transparent liquid, and distils without undergoing any changes. It is soluble in water and alcohol. Nitric acid colors it blood-red; which color afterwards disappears. Subacetate of lead precipitates it completely. Its conversion into the archil red is effected by the action of an alkali, in contact with the air. When dissolved, for example, in ammonia, and exposed to the atmosphere, it takes a dirty brown red hue; but when the orcine is exposed to air charged with vapors of ammonia, it assumes by degrees a fine violet color. To obtain this result, the orcine in powder should be placed in a capsule, alongside of a saucer containing water of ammonia; and both should be covered by a large bell glass; whenever the orcine has acquired a dark brown cast, it must be withdrawn from under the bell, and the excess of ammonia be allowed to volatilize. As soon as the smell of ammonia is gone, the orcine is to be dissolved in water; and then a few drops of ammonia being poured into the brownish liquid, it assumes a magnificent reddish-violet color. Acetic acid precipitates the red lake of lichen.

ORES (*Mines*, Fr.; *Erze*, Germ.), are the mineral bodies which contain so much metal as to be worth the smelting, or being reduced by fire to the metallic state. The substances naturally combined with metals, which mask their metallic characters, are chiefly oxygen, chlorine, sulphur, phosphorus, selenium, arsenic, water, and several acids, of which the carbonic is the most common. Some metals, as gold, silver, platinum, often occur in the metallic state, either alone, or combined with other metals, constituting what are called native alloys.

I have described in the article MINE, the general structure of the great metallic repositories within the earth, as well as the most approved methods of bringing them to the surface; and in the article METALLURGY, the various mechanical and chemical operations requisite to reduce the ores into pure metals. Under each particular metal, moreover, in its alphabetical place, will be found a systematic account of its most important ores.

Relatively to the theory of the smelting of ores, the following observations may be made. It is probable that the coaly matter employed in that process is not the *immediate* agent of their reduction; but the charcoal seems first of all to be transformed by the atmospherical oxygen into the oxyde of carbon; which gaseous product then surrounds and penetrates the interior substance of the oxydes, with the effect of decomposing them, and carrying off their oxygen. That this is the true mode of action, is evident from the well-known facts, that bars of iron, stratified with pounded charcoal, in the steel cementation-chest, most readily absorb the carbonaceous principle to their innermost centre, while their surfaces get blistered by the expansion of carbureted gases formed within; and that an intermixture of ores and charcoal is not always necessary to reduction, but merely an interstratification of the two, without intimate contact of the particles. In this case, the carbonic acid which is generated at the lower surfaces of contact of the strata, rising up through the first bed of ignited charcoal, becomes converted into carbonic oxyde; and this gaseous matter, passing up through the next layer of ore, seizes its oxygen, reduces it to metal, and is itself thereby transformed once more into carbonic acid; and so on in continual alternation. It may be laid down, however, as a general rule, that the reduction is the more rapid and complete, the more intimate the mixture of the charcoal and the metallic oxyde has been, because the formation of both the carbonic acid and carbonic oxyde becomes thereby more easy and direct. Indeed, the cementation of iron bars into steel will not succeed, unless the charcoal be so porous as to contain, interspersed, enough of air to favor the commencement of its conversion into the gaseous oxyde; thus acting like a ferment in brewing. Hence also finely pulverized charcoal does not answer well; unless a quantity of ground iron cinder or oxyde of manganese be blended with it, to afford enough of oxygen to begin the generation of carbonic oxyde gas; whereby the successive transformations into acid, and oxyde, are put in train.

ORPIMENT (Eng. and Fr., *Yellow sulphuret of arsenic*; *Operment*, *Rauschgelb*, Germ.), occurs in indistinct crystalline particles, and sometimes in oblique rhomboidal prisms; but for the most part, in kidney and other imitative forms; it has a scaly and granular aspect; texture foliated, or radiated; fracture small granular, passing into conchoidal; splintery, opaque, shining, with a weak diamond lustre; lemon, orange, or honey yellow; sometimes green; specific gravity, 3·44 to 3·6. It is found in floetz rocks, in marl, clay, sand-stone, along with realgar, lead-glance, pyrites, and blende, in many parts of the world. It volatilizes at the blowpipe. It is used as a pigment.

The finest specimens come from Persia, in brilliant yellow masses, of a lamellar texture, called golden orpiment.

Artificial orpiment is manufactured chiefly in Saxony, by subliming in cast iron cucurbits, surmounted by conical cast-iron capitals, a mixture in due proportions of sulphur and arsenious acid (white arsenic). As thus obtained, it is in yellow compact opaque masses, of a glassy aspect; affording a powder of a pale yellow color. Genuine orpiment is often adulterated with an ill-made compound; which is sold in this country by the preposterous name of king's yellow. This fictitious substance is frequently nothing else than white arsenic combined with a little sulphur; and is quite soluble in water. It is therefore a deadly poison, and has been administered with criminal intentions and fatal effects. I had occasion, some years ago, to examine such a specimen of king's yellow, with which a woman had killed her child. A proper insoluble sulphuret of arsenic, like the native or the Saxon, may be prepared by transmitting sulphureted hydrogen gas through any arsenical solution. It consists of 38·09 sulphur, and 60·92 of metallic arsenic, and is not remarkably poisonous. The finest kinds of native orpiment are reserved for artists; the inferior are used for the indigo vat. They are all soluble in alkaline leys, and in water of ammonia.

ORYCTNOGNOSY is the name given by Werner to the knowledge of minerals; and is therefore synonymous with the English term Mineralogy.

OSTEOCOLLA is the glue obtained from bones, by removing the earthy phosphates with muriatic acid, and dissolving the cartilaginous residuum in water at a temperature considerably above the boiling point, by means of a digester. It is a very indifferent article.

OSMIUM is a metal discovered by Mr. Tennant in 1803, among the grains of native platinum. It occurs also associated with the ore of iridium. As it has not been applied to any use in the arts, I shall reserve any chemical observations that the subject may require for the article PLATINUM.

OXALATES are saline compounds of the bases with

OXALIC ACID (*Acide oxalique*, Fr.; *Sauerkleesaüre*, Germ.), which is the object of a considerable chemical manufacture. It is usually prepared upon the small scale by digesting four parts of nitric acid of specific gravity 1·4, upon one part of sugar, in a glass retort; but on the large scale, in a series of salt-glazed stoneware pipkins, two thirds filled, and set in a water bath. The addition of a little sulphuric acid has been found to increase the product. 15 pounds of sugar yield fully 17 pounds of the crystalline acid. This acid exists in the juice of wood sorrel, the *oxalis acetosella*, in the state of a bi-oxalate; from which the salt is extracted as an object of commerce in Switzerland, and sold under the name of salt of sorrel, or sometimes, most incorrectly, under that of salt of lemons.

Some prefer to make oxalic acid by acting upon 4 parts of sugar, with 24 parts of nitric acid of specific gravity 1·220, heating the solution in a retort till the acid begins to decompose, and keeping it at this temperature as long as nitrous gas is disengaged. The sugar loses a portion of its carbon, which combining with the oxygen of the nitric acid, becomes carbonic acid, and escapes along with the deutoxyde of nitrogen. The remaining carbon and hydrogen of the sugar being oxydized at the expense of the nitric acid, generate a mixture of two acids, the oxalic and the malic. Whenever gas ceases to issue, the retort must be removed from the source of heat, and set aside to cool; the oxalic acid crystallizes, but the malic remains dissolved. After draining these crystals upon a filter funnel, if the brownish liquid be further evaporated, it will furnish another crop of them. The residuary mother water is generally regarded as malic acid, but it also contains both oxalic and nitric acids; and if heated with 6 parts of the latter acid, it will yield a good deal more oxalic acid at the expense of the malic. The brown crystals now formed being, however, penetrated with nitric, as well as malic acid, must be allowed to dry and effloresce in warm dry air, whereby the nitric acid will be got rid of without injury to the oxalic. A second crystallization and efflorescence will entirely dissipate the remainder of the nitric acid, so as to afford pure oxalic acid at the third crystallization. Sugar affords, with nitric acid, a purer oxalic acid, but in smaller quantity, than saw-dust, glue, silk, hairs, and several other animal and vegetable substances.

Oxalic acid occurs in aggregated prisms when it crystallizes rapidly, but in tables of greater or less thickness when slowly formed. They lose their water of crystallization in the open air, fall into powder, and weigh 0·28 less than before; but still retain 0·14 parts of water, which the acid does not part with except in favor of another oxyde, as when it is combined with oxyde of lead. The effloresced acid contains 20 per cent. of water, according to Berzelius. By my analysis, the crystals consist of three prime equivalents, of water = 27, combined with one of dry oxalic acid = 36; or in 100 parts, of 42·86 of water with 57·14 of acid. The acid itself consists of 2 atoms of carbon = 12, + 3 of oxygen = 24; of which the sum is, as above stated, 36. This acid has a sharp sour taste, and sets the teeth on edge; half a pint of water, containing only 1 gr. of acid, very sensibly reddens litmus paper. Nine parts of water dissolve one part of the crystals at 60° F. and form a solution, of spec. grav. 1·045, which when swallowed acts as a deadly poison. Alcohol also dissolves this acid. It differs from all the other acid products of the vegetable kingdom, in containing no hydrogen, as I demonstrated (in my paper upon the ultimate analysis of organic bodies, published in the Phil. Trans. for 1822), by its giving out no muriatic acid gas, when heated in a glass tube with calomel or corrosive sublimate.

Oxalic acid is employed chiefly for certain styles of discharge in calico-printing (which see), and for whitening the leather of boot-tops. Oxalate of ammonia is an excellent re-agent for detecting lime and its salts in any solution. The acid itself, or the bi-oxalate of potash, is often used for removing ink or iron-mould stains from linen.

A convenient plan of testing the value of peroxyde of manganese for bleachers, &c., originally proposed by Berthier, has been since simplified by Dr. Thomson, as follows. In a poised Florence flask weigh 600 grains of water, and 75 grains of crystallized oxalic acid; add 50 grains of the manganese, and as quickly as possible afterwards from 150 to 200 grains of concentrated sulphuric acid. Cover the mouth of the flask with paper, and leave it at rest for 24 hours. The loss of weight it has now suffered, corresponds exactly to the weight of peroxyde of manganese present; because the quantity of carbonic acid producible by the reaction of the oxalic acid with the peroxyde, is precisely equal to the weight of the peroxyde, as the doctrine of chemical equivalents shows.

OXYDES are neutral compounds, containing oxygen in equivalent proportion.

OXYSELS are salts, consisting of oxygenated acids and oxydes, to distinguish them from the HALOSELS, which are salts consisting of one of the archæal elements; such as chlorine, iodine, bromine, &c. combined with metals. See SALT.

OXYGEN (*Oxygène*, Fr.; *Sauerstoff*, Germ.), is a body which can be examined only in the gaseous form; for which purpose it is most conveniently obtained in a pure state by exposing chlorate of potash, or red oxyde of mercury, in a glass retort, or recurved tube, to the heat of a spirit lamp; 100 grains of the salt yield 115 cubic inches of gas. One pound of nitre, ignited in an iron retort, gives out about 1200 cubic inches of oxygen, mixed with a little nitrogen. The peroxyde of manganese also affords it, either by ignition alone in an iron or earthen retort, or by a lamp heat in a glass retort, when mixed with sulphuric acid. Oxygen is void of taste, color, and smell. It possesses all the mechanical properties of the atmosphere. Its specific gravity is 1·1026 compared to air 1·0000; whence 100 cubic inches of it weigh 33·85 grains. Combustibles, even iron and diamonds, once kindled, burn in it most splendidly. It forms 21 parts in 100 by volume of air, being the constituent essential to the atmospheric functions of supporting animal and vegetable life, as well as flame.

The full development of this subject in its multifarious relations, will be discussed in my forthcoming new system of chemistry.

OXYGENATED-MURIATIC, and OXYMURIATIC, are the names originally given by the French chemists, from false theoretical notions, to chlorine, which Sir H. Davy proved to be an undecompounded substance.

P.

PACKFONG is the Chinese name of the alloy called white copper, or German silver.

PACO, or PACOS, is the Peruvian name of an earthy-looking ore, which consists of brown oxyde of iron, with imperceptible particles of native silver disseminated through it.

PADDING MACHINE (*Machine à plaquer*, Fr.; *Klatsch*, or *Grundirmaschine*, Germ.), in calico-printing, is the apparatus for imbuing a piece of cotton cloth uniformly with any mordant. In *fig*. 774, A B C D represents in section a cast iron frame, supporting two opposite standards above M, in whose vertical slot the gudgeons *a b*, of two copper or bronze cylinders E F, run; the gudgeons of E turn upon fixed brasses or plummer blocks; but the superior cylinder F rests upon the surface of the under one, and may be pressed down upon it with greater or less force by means of the weighted lever *d e f g*, whose centre of motion is at *d*, and which bears down upon the axle of F. K is the roller upon which the pieces of cotton cloth intended to be padded are wound; several of them being stitched endwise together. They receive tension from the action of a weighted belt *o, n*, which passes round a pulley *n*, upon the end of the roller K. The trough G, which contains the coloring matter or mordant, rests beneath the cylinder upon the table L, or other convenient support. About two inches above the bottom of the trough, there is a copper dip-roller c, under which the cloth passes, after going round the guide roller *m*. Upon escaping from the trough, it is drawn over the half-round stretcher-bar at I, grooved

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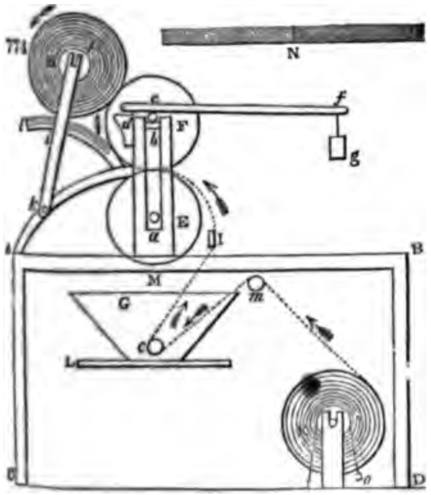
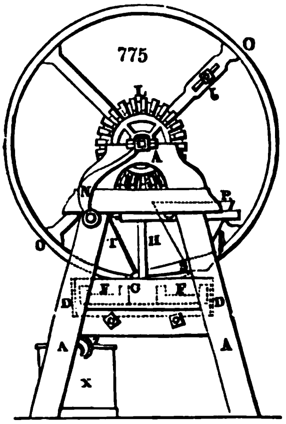


obliquely right and left, as shown at N, whereby it acquires a diverging extension from the middle, and enters with a smooth surface between the two cylinders E F. These are lapped round 6 or 7 times with cotton cloth, to soften and equalize their pressure. The piece of goods glides obliquely upwards, in contact with one third of the cylinder F, and is finally wound about the uppermost roller H. The gudgeon of E revolves in the end of the radius *h*, *k*, which is jointed at *k*, and moveable by a mortise at *i* along the quadrantal arc towards *l*, as the roller K becomes enlarged by the convolutions of the web. The under cylinder E receives motion by a pulley or rigger upon its opposite end, from a band connected with the driving-shaft of the printshop. To ensure perfect equability in the application of the mordant, the goods are in some works passed twice through the trough; the pressure being increased the second time by sliding the weight *g* to the end of the lever *d f*.

A view of a padding machine in connexion with the driving mechanism is given under HOT FLUE; see also STARCHING MACHINE.

PAINT. See ROUGE.

PAINTS, GRINDING OF. There are many pigments, such as common orpiment, or king's yellow, and verdigris, which are strong poisons; others which are very deleterious, and occasion dreadful maladies, such as white lead, red lead, chrome yellow, and vermilion; none of which can be safely ground by hand with the slab and muller, but should always be triturated in a mill. The emanations of white lead cause, first, that dangerous disease the *colica pictonum*, afterwards paralysis, or premature decrepitude and lingering death.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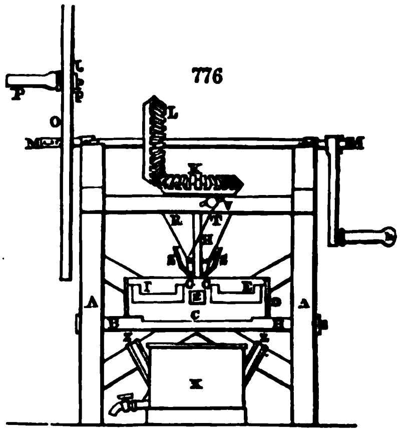
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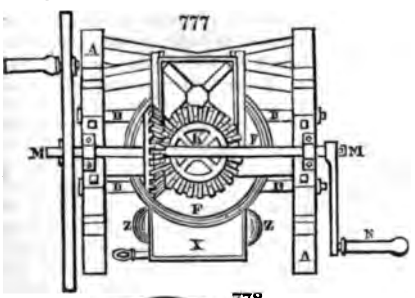
Figs. 775, 776, 777, 778 exhibit the construction of a good color- mill in three views; *fig*. 775 being an elevation shown upon the side of the handle, or where the power is applied to the shaft; *fig*. 776 a second elevation, taken upon the side of the line *c*, *d*, of the plan or bird's-eye view, *fig*. 777.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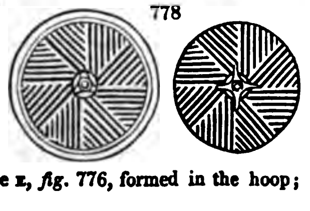
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The frame-work A A of the mill is made of wood or cast iron, strongly mortised or bolted together; and strengthened by the two cross iron bars B, B. *Fig*. 778 is a plan of the millstones. The lying or nether millstone C, *fig*. 776, is of cast iron, and is channelled on its upper face like corn millstones. It is fixed upon the two iron bars B, B; but may be preferably supported upon the 3 points of adjustable screws, passing up through bearing-bars. The millstone C is surrounded by a large iron hoop D, for preventing the pasty-consistenced color from running over the edge. It can escape only by the sluice hole E, *fig*. 776, formed in the hoop; and is then received in the tub X placed beneath.

The upper or moving millstone F, is also made of cast iron. The dotted lines indicate its shape. In the centre it has an aperture with ledges G, G; there is also a ledge upon its outer circumference, sufficiently high to confine the color which may occasionally accumulate upon its surface. An upright iron shaft H passes into the turning stone, and gives motion to it. A horizontal iron bevel wheel K, *figs.* 776, 777, furnished with 27 wooden teeth, is fixed upon the upper end of the upright shaft H. A similar bevel wheel L, having the same number of teeth, is placed vertically upon the horizontal iron axis M, M, and works into the wheel K. This horizontal axis M, M bears, at one of its ends, a handle or winch N, by which the workman may turn the millstone F; and on the other end of the same axis, the fly-wheel O is made fast, which serves to regulate the movements of the machine. Upon one of the spokes of the fly-wheel there is fixed, in like manner, a handle P, which may serve upon occasion for turning the mill. This handle may be attached at any convenient distance from the centre, by means of the slot and screw-nut J.

The color to be ground is put into the hopper R, below which the bucket S is suspended, for supplying the color uniformly through the orifice in the millstone G. A cord or chain T, by means of which the bucket S is suspended at a proper height for pouring out the requisite quantity of color between the stones, pulls the bucket obliquely, and makes its beak rest against the square upright shaft H. By this means the bucket is continually agitated in such a way as to discharge more or less color, according to its degree of inclination. The copper cistern X, receives the color successively as it is ground; and, when full, it may be carried away by the two handles Z, Z; it may be emptied by the stopcock Y, without removing the tub.

PAINTS, VITRIFIABLE. See PORCELAIN, POTTERY, and STAINED GLASS.

PALLADIUM, a rare metal, possessed of valuable properties, was discovered in 1803, by Dr. Wollaston, in native platinum. It constitutes about 1 per cent. of the Columbian ore, and from ¼ to 1 per cent. of the Uralian ore of this metal; occurring nearly pure in loose grains, of a steel-gray color, passing into silver white, and of a specific gravity of from 11·8 to 12·14; also as an alloy with gold in Brazil, and combined with selenium in the Harz near Tilkerode. Into the nitro-muriatic solution of native platinum, if a solution of cyanide of mercury be poured, the pale yellow cyanide of palladium will be thrown down, which being ignited affords the metal. This is the ingenious process of Dr. Wollaston. The palladium present in the Brazilian gold ore may be readily separated as follows: melt the ore along with two or three parts of silver, granulate the alloy, and digest it with heat in nitric acid of specific gravity 1·3. The solution containing the silver and palladium, for the gold does not dissolve, being treated with common salt or muriatic acid, will part with all its silver in the form of a chloride. The supernatant liquor being concentrated and neutralized with ammonia, will yield a rose-colored salt in long silky crystals, the ammonia-muriate of palladium, which being washed in ice-cold water, and ignited, will afford 40 per cent. of metal.

The metal obtained by this process is purer than that by the former; and if it be fused in a crucible along with borax, by the heat of a powerful air-furnace or forge, a button of malleable and ductile palladium will be produced. When a slip of it is heated to redness, it takes a bronze-blue shade of greater or less intensity, as the slip is cooled more or less slowly; but if it be suddenly chilled, as by plunging it into water, it resumes instantly its white lustre. This curious phenomenon depending upon oxydizement and de-oxydizement, in different circumstances, serves at once to distinguish palladium from platinum.

Pure palladium resembles platinum, but has more of a silver hue; when planished by the hammer into a cup, such as that of M. Breant, in the museum of the Mint at Paris, it is a splendid steel-white metal, not liable, like silver, to tarnish in the air. Another cup made by M. Breant, weighing 2 lbs. (1 kilogramme), was purchased by Charles X., and is now in the *garde-meuble* of the French crown. The specific gravity of this metal, when laminated, is stated by Dr. Wollaston at 11·8, and by Vauquelin at 12·1. It melts at from 150° to 160° Wedgewood; and does not oxydize at a white heat. When a drop of tincture of iodine is let fall upon the surface of this metal, and dissipated over a lamp flame, a black spot remains, which does not happen with platinum. A slip of palladium has been used with advantage to inlay the limbs of astronomical instruments, where the fine graduated lines are cut, because it is bright, and not liable to alteration, like silver.

There are a protoxyde and peroxyde of palladium. The proto-chloride consists of 60 of metal and 40 of chlorine; the cyanide, of 67 of metal, and 33 of cyanogen.

PALM OIL (*Huile de palme*, Fr.; *Palmöl*, Germ.), is obtained, in Guinea and Guyana, by expressing, as also by boiling, the fruit of the *avoira elais*. It has an orange color, a smell of violets, a bland taste, is lighter than water, melts at 84° Fahr., becomes rancid and pale by exposure to air, dissolves in boiling alcohol, and consists of 69 parts of oleine, and 31 of stearine, in 100. It is employed chiefly for making yellow soap. It may be bleached by the action of either chlorine or oxygen gas, as also by that of light and heat.

Palm oil, quantity of,

	Imported.	Retained for consumption.	Exported.
Year.	*Cwts.*	*Cwts.*	*Cwts.*
1835.	260,151	242,733	30,915
1836.	277,017	234,357	34,379
1837.	223,329	214,000	

Duty, 1*s*. 3*d*. per cwt.

PAPER CUTTING. Mr. T. B. Crompton, of Farnworth, Lancashire, who obtained a patent in May, 1821, for proposing to conduct the newly formed web of paper in the Fourdrinier machine over heated cylinders, for the purpose of drying it expeditiously, in imitation of the mode so long practised in drying calicoes, obtained, along with Enoch Miller, another, in May, 1828, for cutting the endless web of paper lengthwise, by revolving circular blades, fixed upon a roller, parallel to a cylinder, round which the paper is lapped, and progressively unwound.

A patent had been obtained two months before, for certain improvements in cutting paper, by Mr. Edward Cowper, consisting of a machine, with a reel on which the web of paper of very considerable length has been previously wound, in the act of being made in a Fourdrinier's machine; this web of paper being of sufficient width to produce two, three, or more sheets, when cut.

The several operative parts of the machine are mounted upon standards, or frame-work, of any convenient form or dimensions, and consist of travelling endless tapes to conduct the paper over and under a series of guide rollers; of circular rotatory cutters for the purpose of separating the web of paper into strips equal to the widths of the intended sheets; and of a saw-edged knife, which is made to slide horizontally for the purpose of separating the strips into such portions or lengths as shall bring them to the dimensions of a sheet of paper.

The end of the web of paper from the reel *a*, *fig*. 779, is first conducted up an inclined plane *b* by hand; it is then taken hold of by endless tapes extended upon rollers, as in Mr. Cowper's PRINTING MACHINE, which see. These endless tapes carry the web of paper to the roller *c*, which is pressed against the roller *d* by weighted levers, acting upon the plummer blocks that its axle is mounted in. The second roller *d* may be either of wood or metal, having several grooves formed round its periphery for the purpose of receiving the edges of the circular cutters *e*, (see CARD-CUTTING) mounted upon an axle turning upon bearings in the standards or frame.

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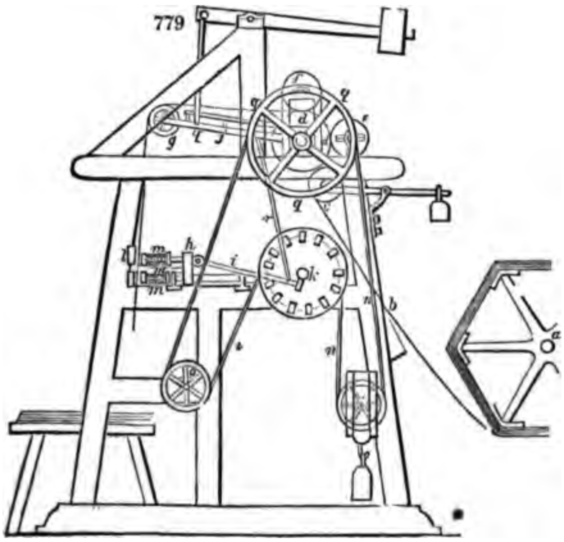


In order to allow the web of paper to proceed smoothly between the two rollers *c*, *d*, a narrow rib of leather is placed round the edges of one or both of these rollers, for the purpose of leaving a free space between them, through which the paper may pass without wrinkling.

From the first roller *c*, the endless tapes conduct the paper over the second *d*, and then under a pressing roller *f*, in which progress the edges of the circular knives *e*, revolving in the grooves of the second roller *d*, cut the web of paper longitudinally into strips of such widths as may be required, according to the number of the circular cutters and distances between them.

The strips of paper proceed onward from between the knife roller *d* and pressing roller *f*, conducted by tapes, until they reach a fourth roller *g*, when they are allowed to descend, and to pass through the apparatus designed to cut them transversely; that is, into sheet lengths.

The apparatus for cutting the strips into sheets is a sliding knife, placed horizontally upon a frame at *h*, which frame, with the knife *e*, is moved to and fro by a jointed rod *i*, connected to a crank on the axle of the pulley *k*. A flat board or plate *l* is fixed to the standard frame in an upright position, across the entire width of the machine; and this board or plate has a groove or opening cut along it opposite to the edge of the knife. The paper descending from the fourth roller *g* passes against the face of this board, and as the carriage with the knife advances, two small blocks, mounted upon rods with springs *m m*, come against the paper, and hold it tight to the board or plate *l*, while the edge of the knife is protruded forwards into the groove of that board or plate, and its sharp saw-shaped teeth passing through the paper, cut one row of sheets from the descending strips; which, on the withdrawing of the blocks, falls down, and is collected on the heap below.

The power for actuating this machine is applied to the reverse end of the axle, on which the pulley *k* is fixed, and a band *n*, *n*, *n*, *n*, passing from this pulley over tension wheels *o*, drives the wheel *q* fixed to the axle of the knife roller *d*; hence this roller receives the rotatory motion which causes it to conduct forward the web of paper, but the other rollers *c* and *f*, are impelled solely by the friction of contact.

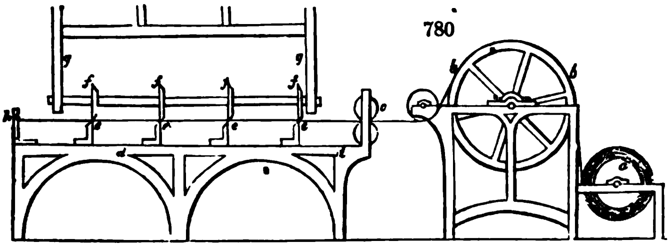
The rotation of the crank on the axle of *k*, through the intervention of the crank-rod *i*, moves the carriage *h*, with the knife, to and fro at certain periods, and when the spring blocks *m* come against the grooved plate *l*, they slide their guide rods into them, while the knife advances to sever the sheets of paper. But as sheets of different dimensions are occasionally required, the lengths of the slips delivered between each return of the knife are to be regulated by enlarging or diminishing the diameter of the pulley *k*, which will of course retard or facilitate the rotation of the three conducting rollers, *c*, *d*, *f*, and cause a greater or less length of the paper to descend between each movement of the knife carriage.

The groove of this pulley *k*, which is susceptible of enlargement, is constructed of wedge-formed blocks passed through its sides, and meeting each other in opposite directions, so that on drawing out the wedges a short distance, the diameter of the pulley becomes diminished; or by pushing the wedges further in, the diameter is increased; and a tension wheel *p* being suspended in a weighted frame, keeps the band always tight.

As it is necessary that the paper should not continue descending while it is held by the blocks *m*, *m* to be cut, and yet that it should be led on progressively over the knife roller *d*, the fourth roller *g*, which hangs in a lever *j*, is made to rise at that time, so as to take up the length of paper delivered, and to descend again when the paper is withdrawn. This is effected by a rod *r*, connected to the crank on the shaft of the aforesaid roller *k*, and also to the under part of the lever *j*, which lever hanging loosely upon the axle of the knife roller *d*, as its fulcrum, vibrates with the under roller *g*, so as to effect the object in the way described.

The patentee states that several individual parts of this machine are not new, and that some of them are to be found included in the specifications of other persons, such as the circular cutters *e*, which are employed by Mr. Dickinson (CARD-CUTTING), and the horizontal cutter *h*, by Mr. Hansard; he therefore claims only the general arrangement of the parts in the form of a machine for the purpose of cutting paper, as the subject of his invention.

The machine for cutting paper contrived by John Dickinson, Esq. of Nash Mill was patented in January, 1829. The paper is wound upon a cylindrical roller *a*, *fig.* 780, mounted upon an axle, supported in an iron frame or standard. From this roller the paper in its breadth is extended over a conducting drum *b*, also mounted upon an axle turning in the frame or standard, and after passing under a small guide roller, it proceeds through a pair of drawing or feeding rollers *c*, which carry it into the cutting machine.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Upon a table *a*, *d*, firmly fixed to the floor of the building, there is a series of chisel-edged knives *e*, *e*, *e*, placed at such distances apart as the dimensions of the cut sheets of paper are intended to be. These knives are made fast to the table, and against them a series of circular cutters *f*, *f*, *f*, mounted in a swinging frame *g*, *g*, are intended to act. The length of paper being brought along the table over the edges of the knives, up to a stop *h*, the cutters are then swung forwards, and by passing over the paper against the stationary knives, the length of paper becomes cut into three separate sheets.

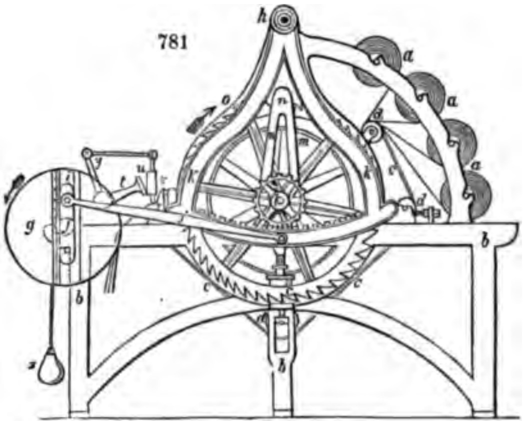
The frame *g*, *g*, which carries the circular cutters *f*, *f*, *f*, hangs upon a very elevated axle, in order that its pendulous swing may move the cutters as nearly in a horizontal line as possible; and it is made to vibrate to and fro by an eccentric, or crank, fixed upon a horizontal rotatory shaft extending over the drum *b*, considerably above it, which may be driven by any convenient machinery.

The workmen draw the paper from between the rollers *c*, and bring it up to the stop *h*, in the intervals between the passing to and fro of the swing-cutters.

The following very ingenious apparatus for cutting the paper web transversely into any desired lengths, was made the subject of a patent by Mr. E. N. Fourdrinier, in June, 1831, and has since been performing its duty well in many establishments.

Fig. 781 is an elevation, taken upon one side of the machine; and *fig.* 782 is a longitudinal section. *a*, *a*, *a*, *a*, are four reels, each covered with one continuous sheet of paper; which reels are supported upon bearings in the frame-work *b*, *b*, *b*. *c*, *c*, *c*, is an endless web of felt cloth passed over the rollers *d*, *d*, *d*, *d*, which is kept in close contact with the under side of the drum *e*, *e*, seen best in *fig.* 782.

781



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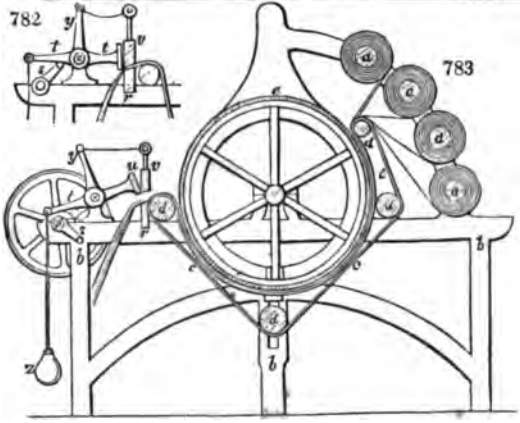


The several parallel layers of paper to be cut, being passed between the drum *e*, and the endless felt *c*, will be drawn off their respective reels, and fed into the machine, whenever the driving-band is slid from the loose to the fast pulley upon the end of the main shaft *f*. But since the progressive advance of the paper-webs must be arrested during the time of making the cross cut through it, the following apparatus becomes necessary. A disc *g*, which carries the pin or stud of a crank *i*, is made fast to the end of the driving shaft *f*. This pin is set in an adjustable sliding piece, which may be confined by a screw within the bevelled graduated groove, upon the face of the disc *g*, at variable distances from the axis, whereby the eccentricity of the stud *i*, and of course the throw of the crank, may be considerably varied. The crank stud *i*, is connected by its rod *j*, to the swinging curvilinear rack *k*, which takes into the toothed wheel *l*, that turns freely upon the axle of the feed drum *e*, *e*. From that wheel the arms *m*, *m*, rise, and bear one or more palls *n*, which work in the teeth of the great ratchet wheel *o*, *o*, mounted upon the shaft of the drum *e*.

The crank-plate *g* being driven round in the direction of its arrow, will communicate a see-saw movement to the toothed arc *k*, next to the toothed wheel *l* in gearing with it, and an oscillatory motion to the arms *m*, *m*, as also to their surmounting palls *n*.

In its swing to the left hand, the catch of the pall will slide over the slope of the teeth of the ratchet wheel *o*; but in its return to the right hand, it will lay hold of these teeth and pull them, with their attached drum, round a part of a revolution. The layers of paper in close contact with the under half of the drum will be thus drawn forward at intervals, from the reels, by the friction between its surface and the endless felt, and in lengths corresponding to the arc of vibration of the pall. The knife for cutting these lengths transversely is brought into action at the time when the swing arc is making its inactive stroke, viz., when it is sliding to the left over the slopes of the ratchet teeth *o*. The extent of this vibration varies according to the distance of the crank stud *i*, from the centre *f*, of the plate g, because that distance regulates the extent of the oscillations of the curvilinear rack, and that of the rotation of the drum *e*, by which the paper is fed forwards to the knife apparatus. The proper length of its several layers being by the above described mechanism carried forward over the bed *r* of the cutting knife or shears *r*, *v*, whose under blade *r* is fixed, the wiper *s*, in its revolution with the shaft *f*, lifts the tail of the lever *t*, consequently depresses the transverse moveable blade *v* (as shown in *fig.* 783), and slides the slanting blades across each other obliquely, like a pair of scissors, so as to cause a clean cut across the plies of paper. But just before the shears begin to operate, the transverse board *u* descends to press the paper with its edge, and hold it fast upon the bed *r*. During the action of the upper blade *v*, against the under *r*, the fall board *u*, is suspended by a cord passing across pulleys from the arm *y* of the bell-crank lever *t*, *t*. Whenever the lifter cam *s*, has passed away from the tail of the bell-crank *t*, the weight *z*, hung upon it, will cause the blade *v*, and the pinching board *u*, to be moved up out of the way of the next length of paper, which is regularly brought forward by the rotation of the drum *e*, as above described. The upper blade of the shears is not set parallel to the shaft of the drum, but obliquely to it, and is, moreover, somewhat curved, so as to close its edge progressively upon that of the fixed blade. The blade *v* may also be set between two guide pieces, and have the necessary motion given to it by levers.

PAPER-HANGINGS, called more properly by the French, *papiers peints*. The art of making paper-hangings, *papier de tenture*, has been copied from the Chinese, among whom it has been practised from time immemorial. The English first imported and began to imitate the Chinese paper-hangings; but being exposed till very lately to a high excise duty upon the manufacture, they have not carried it to that extent and pitch of refinement which the French genius has been enabled to do, unchecked by taxation. The first method of making this paper was stencilling; by laying upon it, in an extended state, a piece of pasteboard having spaces cut out of various figured devices, and applying different water colors with the brush. Another piece of pasteboard with other patterns cut out was next applied, when the former figures were dry, and new designs were thus imparted. By a series of such operations, a tolerable pattern was executed, but with no little labor and expense. The processes of the calico printer were next resorted to, in which engraved blocks of the pear or sycamore were employed to impress the colored designs.

Paper-hangings may be distinguished into two classes; 1. those which are really painted, and which are designed in France under the title of *papiers peints*, with brilliant flowers and figures; and 2. those in which the designs are formed by foreign matters applied to the paper, under the name of *papier tontisse*, or flock paper.

The operations common to paper-hangings of both kinds, may be stated as follows:—

1. The paper should be well sized.
2. The edges should be evenly cut by an apparatus like the bookbinder's press.
3. The ends of each of the 24 sheets which form a piece, should be nicely pasted together; or a Fourdrinier web of paper should be taken.
4. Laying the grounds, is done with earthy colors or colored lakes thickened with size, and applied with brushes.

An expert workman, with one or two children, can lay the grounds of 300 pieces in a day. The pieces are now suspended upon poles near the ceiling, in order to be dried. They are then rolled up and carried to the apartment where they are polished, by being laid upon a smooth table, with the painted side undermost, and rubbed with the polisher. Pieces intended to be satined, are grounded with fine Paris plaster, instead of Spanish white; and are not smoothed with a brass polisher, but with a hard brush attached to the lower end of the swing polishing rod. After spreading the piece upon the table with the grounded side undermost, the paper-stainer dusts the upper surface with finely powdered chalk of Briançon, commonly called talc, and rubs it strongly with the brush. In this way the satiny lustre is produced.

THE PRINTING OPERATIONS.

Blocks about two inches thick, formed of three separate boards glued together, of which two are made of poplar, and one (that which is engraved) of pear-tree or syca more, are used for printing paper-hangings, as for calicoes. The grain of the upper layer of wood should be laid across that of the layer below. As many blocks are required as there are colors and shades of color. To make the figure of a rose, for example, three several reds must be applied in succession, the one deeper than the other, a white for the clear spaces, two and sometimes three greens for the leaves, and two wood colors for the stems; altogether from 9 to 12 for a rose. Each block carries small pin points fixed at its corners to guide the workman in the insertion of the figure exactly in its place. An expert hand places these guide pins so that their marks are covered and concealed by the impression of the next block; and the finished piece shows merely those belonging to the first and last blocks.

In printing, the workman employs the same *swimming-tub* apparatus which has been described under block printing (see Calico-printing), takes off the color upon his blocks, and impresses them on the paper extended upon a table in the very same way. The tub in which the drum or frame covered with calf-skin is inverted, contains simply water thickened with parings of paper from the bookbinder, instead of the pasty mixture employed by the calico-printers. In impressing the color by the block upon the paper, he employs a lever of the second kind, to increase the power of his arm, making it act upon the block through the intervention of a piece of wood, shaped like the bridge of a violin. This tool is called *tasseau* by the French. A child is constantly occupied in spreading color with a brush upon the calf-skin head of the drum or sieve, and in sliding off the paper upon a wooden trestle or horse, in proportion as it is finished. When the piece has received one set of colored impressions, the workman, assisted by his little aid, called a *tireur* (drawer), hooks it upon the drying-poles under the ceiling. A sufficient number of pieces should be provided to keep the printer occupied during the whole at least of one day, so that they will be dried and ready to receive another set of colored impressions by the following morning.

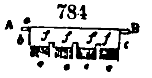
All the colors are applied in the same manner, every shade being formed by means of the blocks, which determine all the beauty and regularity of the design. A pattern drawer of taste may produce a very beautiful effect. The history of Psyche and Cupid, by M. Dufour, has been considered a masterpiece in this art, rivalling the productions of the pencil in the gradation, softness, and brilliancy of the tints.

When the piece is completely printed, the workman looks it all over, and if there be any defects, he corrects them by the brush or pencil, applying first the correction of one color, and afterwards of the rest.

A final satining, after the colors are dried, is communicated by the friction of a finely polished brass roller, attached by its end gudgeons to the lower extremity of a long swing-frame; and acting along the cylindrical surface of a smooth table, upon which the paper is spread.

The *fondu* or rainbow style of paper-hangings, which I have referred to this place in the article Calico-printing, is produced by means of an assortment of oblong narrow tin pans, fixed in a frame, close side to side, each being about one inch wide, two inches deep, and eight inches long; the colors of the prismatic spectrum, red, orange, yellow, green, &c., are put, in a liquid state, successively in these pans; so that when the oblong brush A, B, with guide ledges *a*, *c*, *d*, is dipped into them across the whole of the parallel row at once, it comes out impressed with the different colors at successive points *e*, *e*, *e*, *e*, of its length, and is then drawn by the paper-stainer over the face of the woollen drum head, or sieve of the swimming tub, upon which it leaves a corresponding series of stripes in colors, graduating into one another like those of the prismatic spectrum. By applying his block to the *tear*, the workman takes up the color in rainbow hues, and transfers these to the paper. *f*, *f*, *f*, *f* show the separate brushes in tin sheaths, set in one frame.

784



At M. Zuber's magnificent establishment in the ancient château of Rixheim, near Mulhouse, where the most beatiful French *papiers peints* are produced, and where I was informed that no less than 3000 blocks are required for one pattern, I saw a two-color calico machine employed with great advantage, both as to taste and expedition. Steam-charged cylinders were used to dry the paper immediately after it was printed, as the colors, not being so rapidly absorbed as they are by calico, would be very apt to spread.

The operations employed for common paper-hangings, are also used for making flock paper, only a stronger size is necessary for the ground. The flocks are obtained from the woollen cloth manufacturers, being cut off by their shearing machines, called *lewises* by the English workmen, and are preferred in a white state by the French paper-hanging makers, who scour them well, and dye them of the proper colors themselves. When they are thoroughly stove-dried, they are put into a conical fluted mill, like that for making snuff, and are properly ground. The powder thus obtained is afterwards sifted by a bolting-machine, like that of the flour mill, whereby flocks of different degrees of fineness are produced. These are applied to the paper after it has undergone all the usual printing operations. Upon the workman's left hand, and in a line with his printing table, a large chest is placed for receiving the flock powders: it is seven or eight feet long, two feet wide at the bottom, three feet and a half at top, and from 15 to 18 inches deep. It has a hinged lid. Its bottom is made of tense calf-skin. This chest is called the *drum;* it rests upon four strong feet, so as to stand from 24 to 28 inches above the floor.

The block which serves to apply the adhesive basis of the velvet-powders, bears in relief only the pattern corresponding to that basis, which is formed with linseed oil, rendered drying by being boiled with litharge, and afterwards ground up with white lead. The French workmen call this mordant the *encaustic.* It is put upon the cloth which covers the inverted swimming tub, in the same way as the common colors are, and is spread with a brush by the *tireur* (corruptly styled *tearer* by some English writers). The workman daubs the blocks upon the mordant, spreads the pigment even with a kind of brush, and then applies it by impression to the paper. Whenever a sufficient surface of the paper has been thus covered, the child draws it along into the great chest, sprinkling the flock powder over it with his hands; and when a length of 7 feet is printed, he covers it up within the drum, and beats upon the calf-skin bottom with a couple of rods to raise a cloud of flock inside, and to make it cover the prepared portion of the paper uniformly. He now lifts the lid of the chest, inverts the paper, and beats its back lightly, in order to detach all the loose particles of the woolly powder.

By the operation just described, the velvet-down being applied everywhere of the same color, would not be agreeable to the eye, if shades could not be introduced to relieve the pattern. To give the effect of drapery, for example, the appearance of folds must be introduced. For this purpose, when the piece is perfectly dry, the workman stretches it upon his table, and by the guidance of the pins in his blocks, he applies to the flock surface a color in distemper, of a deep tint, suited to the intended shades, so that he dyes the wool in its place. Light shades are produced by applying some of his lighter water-colors.

Gold leaf is applied upon the above mordant, when nearly dry; which then forms a proper gold size; and the same method of application is resorted to, as for the ordinary gilding of wood. When the size has become perfectly hard, the superfluous gold leaf is brushed off with a dossil of cotton wool or fine linen.

The colors used by the paper-hangers are the following:—

1. *Whites.* These are either white-lead, good whitening, or a mixture of the two.
2. *Yellows.* These are frequently vegetable extracts; as those of weld, or of Avignon or Persian berries, and are made by boiling the substances with water. Chrome yellow is also frequently used, as well as the *terra di Sienna* and yellow ochre.
3. *Reds* are almost exclusively decoctions of Brazil wood.
4. *Blues* are either Prussian blue, or blue verditer.
5. *Greens* are Scheele's green, a combination of arsenious acid, and oxyde of copper; the green of Schweinfurth, or green verditer; as also a mixture of blues and yellows.
6. *Violets* are produced by a mixture of blue and red in various proportions, or they may be obtained directly by mixing a decoction of logwood with alum.
7. *Browns, blacks, and grays.* Umber furnishes the brown tints. Blacks are either common ivory or Frankfort black; and grays are formed by mixtures of Prussian blue and Spanish white.

All the colors are rendered adhesive and consistent, by being worked up with gelatinous size or a weak solution of glue, liquefied in a kettle. Many of the colors are previously thickened, however, with starch. Sometimes colored lakes are employed. See LAKES.

PAPER, MANUFACTURE OF. (*Papeterie,* Fr.; *Papiermacherkunst,* Germ.) This most useful substance, which has procured for the moderns an incalculable advantage over the ancients, in the means of diffusing and perpetuating knowledge, seems to have been first invented in China, about the commencement of the Christian era, and was thence brought to Mecca, along with the article itself, about the beginning of the 8th century; whence the Arabs carried it, in their rapid career of conquest and colonization, to the coasts of Barbary, and into Spain, about the end of the 9th or beginning of the 10th century.

By other accounts, this art originated in Greece, where it was first made from cotton fibres, in the course of the tenth century, and continued there in common use during the next three hundred years. It was not till the beginning of the 14th century that paper was made from linen in Europe, by the establishment of a paper-mill in 1390, at Nuremberg in Germany. The first English paper-mill was erected at Dartford by a German jeweller in the service of Queen Elizabeth, about the year 1588. But the business was not very successful; in consequence of which, for a long period afterwards, indeed till within the last 70 years, this country derived its supplies of fine writing papers from France and Holland. Nothing places in a more striking light the vast improvement which has taken place in all the mechanical arts of England since the era of Arkwright, than the condition of our paper-machine factories now, compared with those on the Continent. Almost every good automatic paper mechanism at present mounted in France, Germany, Belgium, Italy, Russia, Sweden, and the United States, has either been made in Great Britain, and exported to these countries, or has been constructed in them closely upon the English models.

Till within the last 30 years, the linen and hempen rags from which paper was made, were reduced to the pasty state of comminution requisite for this manufacture by mashing them with water, and setting the mixture to ferment for many days in close vessels, whereby they underwent in reality a species of putrefaction. It is easy to see that the organic structure of the fibres would be thus unnecessarily altered, nay, frequently destroyed. The next method employed, was to beat the rags into a pulp by stamping rods, shod with iron, working in strong oak mortars, and moved by water-wheel machinery. So rude and ineffective was the apparatus, that forty pairs of stamps were required to operate a night and a day, in preparing one hundred weight of rags. The pulp or paste was then diffused through water, and made into paper by methods similar to those still practised in the small hand-mills.

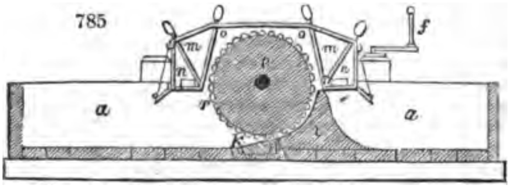
About the middle of the last century, the cylinder or engine mode, as it is called, of comminuting rags into paper pulp, was invented in Holland; which was soon afterwards adopted in France, and at a later period in England.

The first step in the paper manufacture, is the sorting of the rags into four or five qualities. They are imported into this country chiefly from Germany, and the ports of the Mediterranean. At the mill they are sorted again more carefully, and cut into shreds by women. For this purpose a table frame is covered at top with wire cloth, containing about nine meshes to the square inch. To this frame a long steel blade is attached in a slanting position, against whose sharp edge the rags are cut into squares or fillets, after having their dust thoroughly shaken out through the wire cloth. Each piece of rag is thrown into a certain compartment of a box, according to its fineness; seven or eight sorts being distinguished. An active woman can cut and sort nearly one cwt. in a day.

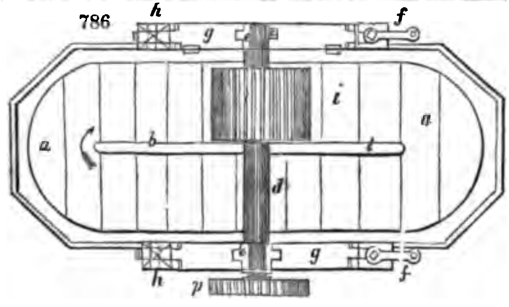
The sorted rags are next dusted in a revolving cylinder surrounded with wire cloth, about six feet long, and four feet in diameter, having spokes about 20 inches long, attached at right angles to its axis. These prevent the rags from being carried round with the case, and beat them during its rotation; so that in half an hour, being pretty clean, they are taken out by the side door of the cylinder, and transferred to the engine, to be first washed, and next reduced into a pulp. For fine paper, they should be previously boiled for some time in a caustic ley, to cleanse and separate their filaments.

The construction of the *stuff-engine* is represented in *figs.* 785, 786. *Fig.* 785 is the longitudinal section, and *fig.* 786 the plan of the engine. The large vat is an oblong cistern rounded at the angles. It is divided by the partition *b*, *b*, and the whole inside is lined with lead. The cylinder *c*, is made fast to the spindle *d*, which extends across the engine, and is put in motion by the pinion *p*, fixed to its extremity. The cylinder is made of wood, and furnished with a number of blades or cutters, secured to its circumference, parallel to the axis, and projecting about an inch above its surface. Immediately beneath the cylinder a block of wood *k* is placed. This is mounted with cutters like those of the cylinder, which in their revolution pass very near to the teeth of the block, but must not touch it. The distance between these fixed and moving blades is capable of adjustment by elevating or depressing the bearings upon which the necks *e*, *e*, of the shaft are supported. These bearings rest upon two levers *g*, *g*, which have tenons at their ends, fitted into upright mortises, made in short beams *h*, *h*, bolted to the sides of the engine. The one end of

785



786



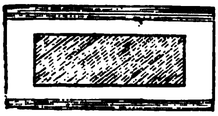
the levers *g*, *g*, is moveable, while the other end is adapted to rise and fall upon bolts in the beams *h*, *h*, as centres. The front lever, or that nearest to the cylinder *c*, is capable of being elevated or depressed, by turning the handle of a screw (not seen in this view), which acts in a nut fixed to the tenon of *g*, and comes up through the top of the beam *h*, upon which the head of the screw takes its bearing. Two brasses are let into the middle of the levers *g*, *g*, and form the bearings for the shaft of the engine to turn upon. The above-mentioned vertical screw is used to raise or lower the cylinder, and cause it to cut coarser or finer, by enlarging or diminishing the space between the fixed cutters in the block and those in the cylinder.

To the left hand of *i*, *fig.* 785, is a circular breasting made of boards, and covered with sheet lead; it is curved to fit the cylinder very truly, and leaves but very little space between the teeth and breasting; at its bottom, the block *k* is fixed. The engine is supplied with water from a pump, by a pipe, which delivers it into a small cistern, near to and communicating with the engine. A stopcock cuts off or regulates the supply of water at pleasure, and a grating covered with hair-cloth is fixed across that small cistern, to intercept any filth that may be floating in the water; in other cases a flannel bag is tied round the nose of the stopcock, to act as a filter.

The rags being put into the engine filled with water, are drawn by the rapid rotation of the cylinder between the two sets of cutters, whereby they are torn into the finest filaments, and by the impulsion of the cylinder they are floated over the top of the breasting upon the inclined plane. In a short time more rags and water are raised into that part of the engine vat. The tendency in the liquid to maintain an equilibrium, puts the whole contents of the cistern in slow motion down the inclined plane, to the left hand of *i*, and round the partition *b*, *b*, (see the arrow), whereby the rags come to the cylinder again in the space of about 20 minutes; so that they are repeatedly drawn out and separated in all directions till they are reduced to the appearance of a pulp.

This circulation is particularly useful, by turning over the rags in the engine, causing them to be presented to the cutter at different angles every time; otherwise, as the blades always act in one direction, the comminution would not be so complete. The cutting is performed as follows: The teeth of the block are set somewhat obliquely to the axes of the cylinder, as shown by *fig.* 787; but the teeth of the cylinder *c* itself are set parallel to its axis; therefore the cutting edges meet at a small angle, and come in contact, first at the one end, and then towards the other, by successive degrees, so that any rags coming between them, are torn as if between the blades of a pair of forceps. Sometimes the blades *k* in the block are bent to an angle in the middle, instead of being straight and inclined to the cylinder. These are called elbow plates; their two ends being inclined in opposite directions to the axis of the cylinder. In either case, the edges of the plates of the block cannot be straight lines, but must be curved, to adapt themselves to the curve which a line traced on the cylinder will necessarily have. The plates or blades are united by screwing them together, and fitting them into a cavity cut into the wooden block *k*. Their edges are bevelled away upon one side only.

787



The block is fixed in its place by being made dovetailed, and truly fitted into the bottom of the cistern, so that the water will not leak through its junction. The end of it comes through the woodwork of the chest, and projects to a small distance on its outside, being kept in its place by a wedge. By withdrawing this wedge, the block becomes loose, and can be removed in order to sharpen the cutters, as occasion may be. This is done at a grindstone, after detaching the plates from each other.

The cutters of the cylinder are fixed into grooves, cut in the wood of the cylinder, at equal distances asunder, round its periphery, in a direction parallel to its axis. The number of these grooves is twenty, in the machine here represented. For the *washer*, each groove has two cutters put into it; then a fillet of wood is driven fast in between them, to hold them firm; and the fillets are secured by spikes driven into the solid wood of the cylinder. The *beater* is made in the same manner, except that each groove contains three bars and two fillets.

In the operation of the cylinder, it is necessary that it should be enclosed in a case, or it would throw all the water and rags out of the engine, in consequence of its great velocity. This case is a wooden box *m*, *m*, *fig.* 785, enclosed on every side except the bottom; one side of it rests upon the edge of the vat, and the other upon the edge of the partition *b*, *b*, *fig.* 786. The diagonal lines *m*, *r*, represent the edges of wooden frames, which are covered with hair or wire-cloth, and immediately behind these the box is furnished with a bottom and a ledge towards the cylinder, so as to form a complete trough. The square figures under *n*, *n*, in *fig.* 785, show the situation of two openings or spouts through the side of the case, which conduct to flat lead-pipes, one of which is seen near the upper *g* in *fig.* 786, placed by the side of the vat; the beam being cut away from them. These are waste pipes to discharge the foul water from the engine; because the cylinder, as it turns, throws a great quantity of water and rags up against the sieves; the water goes through them, and runs down to the trough under *n*, *n*, and thence into the ends of the flat leaden pipes, through which it is discharged. *o*, *o*, *fig.* 785, are grooves for two boards, which, when put down in their places, cover the hair sieves, and stop the water from going through them, should it be required in the engine. This is always the case in the beating engines, and therefore they are seldom provided with these waste pipes, or at most on one side only; the other side of the cover being curved to conform to the cylinder. Except this, the only difference between the washing engine and the beater, is that the teeth of the latter are finer, there being 60 instead of 40 blades in the periphery; and it revolves quicker than the washer, so that it will tear out and comminute those particles which pass through the teeth of the washer. In small mills, when the supply of water is limited, there is frequently but one engine, which may be used both for washing and beating, by adjusting the screw so as to let the cylinder down and make its teeth work finer. But the system in all considerable works, is to have two engines at least, or four if the supply of water be great. The power required for a 5 or 6 vat mill, is about 20 horses in a water-wheel or steam engine.

In the above figures only one engine is shown, namely, the *finisher;* there is another, quite similar, placed at its end, but on a level with its surface, which is called the *washer*, in which the rags are first worked coarsely with a stream of water, running through them to wash and open their fibres; after this washing they are called *half-stuff*, and are then let down into the bleaching engine, and next into the *beating* engine, above described.

By the arrangements of the mill gearing, the two cylinders of the *washer* and *beater* engines make from 120 to 150 revolutions per minute, when the water-wheel moves with due velocity. The beating engine is always made to move, however, much faster than the washing one, and nearly in the ratio of the above numbers.

The vibratory noise of a washing engine is very great; for when it revolves 120 times per minute, and has 40 teeth, each of which passes by 12 or 14 teeth in the block at every revolution, it will make nearly 60,000 cuts in a minute, each of them sufficiently loud to produce a most grating growling sound. As the beater revolves quicker, having perhaps 60 teeth, instead of 40, and 20 or 24 cutters in the block, it will make 180,000 cuts in a minute. This astonishing rapidity produces a coarse musical humming, which may be heard at a great distance from the mill. From this statement, we may easily understand how a modern engine is able to turn out a vastly greater quantity of paper pulp in a day than an old mortar machine.

The operation of grinding the rags requires nice management. When first put into the washing engine they should be worked gently, so as not to be cut, but only powerfully scrubbed, in order to enable the water to carry off the impurities. This effect is obtained by raising the cylinder upon its shaft, so that its teeth are separated considerably from those of the block. When the rags are comminuted too much in the washer, they would be apt to be carried off in part with the stream, and be lost; for at this time the water-cock is fully open. After washing in this way for 20 or 30 minutes, the bearings of the cylinder are lowered, so that its weight rests upon the cutters. Now the supply of water is reduced, and the rags begin to be torn, at first with considerable agitation of the mass, and stress upon the machinery. In about three or four hours, the engine comes to work very smoothly, because it has by this time reduced the rags to the state of *half-stuff*. They are then discharged into a large basket, through which the water drains away.

The bleaching is usually performed upon the *half-stuff*. At the celebrated manufactory of Messrs. Montgolfier, at Annonay, near Lyons, chlorine gas is employed for this purpose with the best effect upon the paper, since no lime or muriate of lime can be thus left in it; a circumstance which often happens to English paper, bleached in the washing engine by the introduction of chloride of lime among the rags, after they have been well washed for three or four hours by the rotation of the engine. The current of water is stopped whenever the chloride of lime is put in. From 1 to 2 pounds of that chemical compound are sufficient to bleach 1 cwt. of fine rags, but more must be employed for the coarser and darker colored. During the bleaching operation the two sliders *o*, *o*, *fig.* 785, are put down in the cover of the cylinder, to prevent the water getting away. The engine must be worked an hour longer with the chloride of lime, to promote its uniform operation upon the rags. The cylinder is usually raised a little during this period, as its only purpose is to agitate the mass, but not to triturate it. The water-cock is then opened, the boards *m*, *m* are removed, and the washing is continued for about an hour, to wash the salt away; a precaution which ought to be better attended to than it always is by paper manufacturers.

The half-stuff thus bleached is now transferred to the beating engine, and worked into a fine pulp. This operation takes from 4 to 5 hours, a little water being admitted from time to time, but no current being allowed to pass through, as in the washing engine.

The softest and fairest water should be selected for this purpose; and it should be administered in nicely regulated quantities, so as to produce a proper spissitude of stuff for making paper.

For printing paper, the *sizing* is given in the beating engine, towards the end of its operation. The size is formed of alum in fine powder, ground up with oil; of which mixture about a pint and a half are thrown into the engine at intervals, during the last half-hour's beating. Sometimes a little indigo blue or smalt is also added, when a peculiar bloom color is desired. The pulp is now run off into the stuff chest, where the different kinds are mixed; whence it is taken out as wanted. The chest is usually a rectangular vessel of stone or wood lined with lead, capable of containing 300 cubic feet at least, or 3 engines full of stuff. Many paper-makers prefer round chests, as they admit of rotatory agitators.

When the paper is made in single sheets, by hand labor, as in the older establishments, a small quantity of the stuff is transferred to the working-vat by means of a pipe, and there diluted properly with water. This vat is a vessel of stone or wood, about 5 feet square, and 4 deep, with sides somewhat slanting. Along the top of the vat a board is laid, with copper fillets fastened lengthwise upon it, to make the mould slide more easily along. This board is called the bridge. The maker stands on one side; and has to his left hand a smaller board, one end of which is made fast to the bridge, while the other rests on the side of the vat. In the bridge opposite to this, a nearly upright piece of wood, called the ass, is fastened. In the vat there is a copper, which communicates with a steam pipe to keep it hot; there is also an agitator, to maintain the stuff in a uniform consistence.

The moulds consist of frames of wood, neatly joined at the corners, with wooden bars running across, about an inch and a half apart. Across these, in the length of the moulds, the wires run, from fifteen to twenty per inch. A strong raised wire is laid along each of the cross bars, to which the other wires are fastened; this gives the laid paper its ribbed appearance.

The water-mark is made by sewing a raised piece of wire in the form of letters, or any figured device, upon the wires of the mould, which makes the paper thinner in these places. The frame-work of a *wove* mould is nearly the same; but instead of sewing on separate wires, the frame is covered with fine wire cloth, containing from 48 to 64 meshes per inch square. Upon both moulds a *deckel*, or moveable raised edge-frame, is used; which must fit very neatly, otherwise the edges of the paper will be rough.

A pair of moulds being laid upon the bridge, the workman puts on the deckel, brings the mould into a vertical position, dips it about half way down into the stuff before him, then turning it into a horizontal position, covers the mould with the stuff and shakes it gently. This is a very delicate operation; for if the mould be not held perfectly level, one part of the sheet will be thicker than another. The sheet thus formed has, however, no coherence; so that by turning the mould, and dipping the wire cloth surface in the vat, it is again reduced to pulp if necessary. He now pushes the mould along the small board to the left, and removes the deckel. Here another workman called the *coucher* receives it, and places it at rest upon the ass, to drain off some of the water. Meanwhile the *vat-man* puts the deckel upon the other mould, and makes another sheet. The coucher stands to the left side of the vat, with his face towards the vat-man or maker, on his right is the press furnished with felt cloths, or porous flannels; a three-inch thick plank lies before him on the ground. On this he lays a cushion of felts, and on this another felt; he then turns the paper wire mould, and presses it upon the felt, where the sheet remains. He now returns the mould by pushing it along the bridge. The maker has by this time another sheet ready for the coucher; which, like the preceding, is laid upon the ass, and then couched or inverted upon another felt, laid down for the purpose.

In this way, felts and paper are alternately stratified, till a heap of six or eight quires is formed, which is from 15 to 18 inches high. This mass is drawn into the press, and exposed to a force of 100 tons or upwards. After it is sufficiently compressed, the machine is relaxed, and the elasticity of the flannel makes the rammer descend (if a hydraulic press be used) with considerable rapidity. The felts are then drawn out on the other side by an operative called a *layer*, who places each felt in succession upon one board, and each sheet of paper upon another. The coucher takes immediate possession of the felts for his further operations.

Two men at a vat, and a boy as a layer or lifter, can make about 6 or 8 reams in 10 hours. In the evening the whole paper made during the day is put into another press, and subjected to moderate compression, in order to get quit of the mark of the felt, and more of the water. Next day it is all separated, a process called parting, and being again pressed, is carried into the loft. Fine papers are often twice parted and pressed, in order to give them a proper surface.

The next operation is the drying, which is performed in the following way. Posts about 10 or 12 feet high are erected at the distance of ten feet from each other, and pierced with holes six inches apart; two spars with ropes stretched between them, at the distance of 5 inches from one another, called a treble or tribble, are placed about 5 feet high between these posts, supported by pins pushed into the holes in the posts. The workman takes up 4 or 8 sheets of paper, and puts them upon a piece of wood in the form of a T; passing this T between the ropes, he shifts the sheets upon them, and proceeds thus till all the ropes are full. He then raises the treble, and puts another in its place, which he fills and raises in like manner. Nine or ten trebles are placed in every set of posts. The sides of the drying-room have proper shutters, which can be opened to any angle at pleasure.

When the paper is dry, it is taken down, and laid neatly in heaps to be sized. Size is made of pieces of skin, cut off by the curriers before tanning, or sheep's feet, or any other matter containing much gelatine. These substances are boiled in a copper to a jelly; to which, when strained, a small quantity of alum is added. The workman then takes about 4 quires of paper, spreads them out in the size properly diluted with water, taking care that they be equally moistened. This is rather a nice operation. The superfluous size is then pressed out, and the paper is parted into sheets. After being once more pressed, it is transferred to the drying-room, but must not be dried too quickly. Three days are required for this purpose. When the paper is thoroughly dry, it is carried to the finishing-house, and is again pressed pretty hard. It is then picked by women with small knives, in order to take out the knots, and separate the perfect from the imperfect sheets. It is again pressed, given to the finisher, to be counted into reams, and done up. These reams are compressed, tied up, and sent to the warehouse for sale. A good finisher can count 200 reams, or 96,000 sheets in a day.

Hot pressing is executed by placing a sheet of paper between two smoothed pasteboards, alternately, and between every 50 pasteboards a heated plate of iron, and subjecting the pile to the press. This communicates a fine smooth surface to writing-paper.

The grain of the paper is often disfigured by the felts, when they are too much used, or when the loose fibres do not cover the twisted thread. The two sides of the felt are differently raised, and that on which the fibres are longest is applied to the sheets which are laid down. As the felts have to resist the reiterated action of the press, their warp should be made stout, of long combed wool, and well twisted. The woof, however, should be of carded wool, and spun into a soft thread, so as to render the fabric spongy, and capable of imbibing much water.

This operose and delicate process of moulding the sheets of paper by hand, has for nearly thirty years past been performed, in many manufactories, by a machine which produces it in a continuous sheet of indefinite length which is afterwards cut into suitable sizes, by the PAPER-CUTTING MACHINE.

In 1799, Louis Robert, then employed in the paper works of Essonne in France, contrived a machine to make paper of a great size, by a continuous motion, and obtained for it a patent for 15 years, with a sum of 8000 francs from the French government, as a reward for his ingenuity. The specification of this patent is published in the second volume of *Brevets d' Invention expirés.* M. Leger-Didot, then director of the said works, bought Robert's machine and patent for 25,000 francs, to be paid by instalments. Having become proprietor of this machine, which, though imperfect, contained the germ of a valuable improvement in paper-making, M. Didot came over with it to England, where he entered into several contracts for constructing and working it.

Meanwhile M. L. Didot having failed to fulfil his obligations to Robert, the latter instituted a law-suit, and recovered possession of his patent by a decision dated 23d June, 1810. Didot then sent over to Paris the Repertory of Arts, for Sept. 1808, which contained the specification of the English patent, with instructions to a friend to secure the improved machines described in it, by a French patent. The patent was obtained, but became inoperative in consequence of M. L. Didot failing to return to France, as he had promised, so as to mount the patent machine within the two years required by the French patent law. It was not till 1815, that M. Calla, machine-maker at Paris, constructed the paper apparatus known in England by the name of Fourdrinier's, and which, on the authority of the *Dictionnaire Technologique*, was very imperfect in comparison of an English made machine imported about that time into France. *La construction de ces machines, qui n'offre pourtant rien de difficile, est restée jusqu' à ce jour exclusivement dans les mains des Anglais*, is the painful acknowledgment made in 1829, for his countrymen, by the author of the elaborate article Papeterie in that national work. If there be nothing difficult in the construction of these machines, the French mechanicians ought to be ashamed of forcing their countrymen to seek the sole supply of them in England; for the principal paper works in France, as those of MM. Canson, Montgolfier, Thomas Varenne, Firmin Didot, Delcambre, De Maupeon, &c., are mounted with English-made machines.

The following, for example, are a few of the paper-mills in France which are mounted with the self-acting machines of Messrs. Bryan Donkin & Co.

Messrs. Canson, at Annonay.
M. de la Place, at Jean d'Heures, Bar-le-duc.
Société anonyme, at Sainte Marie, under M. Delatouche.
Echarcon près Mennecy, (Seine et Oise).
Firmin Didot, Mesnil sur l'Estrée.
M. F. M. Montgolfier, à Annonay.
Muller, Bouchard, Ondin and Co's., at Gueures, near Dieppe.
MM. Richard et Comp. à Plainfoing.
M. Callot-Bellisle; Vieuze et Chantoiseau.
M. Bechétaile, near St. Etienne, at Bourg Argental.

It deserves particularly to be remarked, to the honor of English mechanism, that the proprietors of the first five of the above works received gold medals at the last exposition of their papers at the Louvre, and all the rest received medals either of silver or bronze.[*]

The following is a true narrative of the rise and progress of the paper automaton.

M. Leger Didot, accompanied by Mr. John Gamble, an Englishman who had resided for several years in Paris, obtained permission from the French government, in 1800, to carry over the small working model of Robert's continuous machine, with the view of getting the benefit of English capital and mechanical skill to bring it into an operative state upon the great scale. Fortunately for the vigorous development of this embryo project, which had proved an abortion in France, they addressed themselves, on the one hand, to a mercantile firm equally opulent and public spirited, and on the other, to engineers distinguished for persevering energy and mechanical resource. A first patent was granted to Mr. Gamble on the 20th of April, 1801, and a second, for certain improvements upon the former, on the 7th of June, 1803. In January, 1804, Mr. Gamble, for certain considerations, assigned these two patents to Messrs. Henry and Sealy Fourdrinier, the house above alluded to, who were at that period, and for several years afterwards, the most considerable stationers and paper-makers in Great Britain. By an act of parliament passed on the 4th of August, 1807, Mr. Gamble's privilege of 14 years from April, 1801, was prolonged to 15 years after the date of the act, being an extension of about 7 years upon the original patent.

The proprietors showed good reasons, in the enormous expense of their experiments, and the national importance of the object, why the patent should have been extended 14 years from the latter date, and would have obtained justice from parliament in this respect, but for an unworthy artifice of Lord Lauderdale in the House of Lords. "He, and he only, was the person who took the objection," and, by introducing a regulation in a standing order of the House of Lords, that none but the original inventor should have an extension, though Mr. H. Fourdrinier was the inventor substantially of the operative machine, he defeated the honorable intentions of his brother peers, whose committee said, "We will give seven years, and Mr. Fourdrinier may apply again, if it should turn out that the seven years that we propose to give to Mr. Fourdrinier should not give sufficient time to afford any chance of his receiving any remuneration for the expense that he has incurred in introducing this invention." The bill passed in the House of Commons for 14 years, but it was limited by this *ruse* of Lord Lauderdale to 7, "who put the standing order upon the books (of the upper house) which prevented Messrs. Fourdrinier from having any benefit from the invention.[†]

In February, 1808, Mr. Gamble, after losing both his time and money savings during eight years of irksome diligence, assigned over to Messrs. Fourdrinier the whole right of his share in the patent to which he was entitled under the act of parliament.

Dartford in Kent, which had been long conspicuous as the seat of a good manufactory of paper and paper moulds, was selected by the proprietors of the patent as the fittest place for realizing their plans; and happily for them it possessed, in Mr. Hall's engineering establishment, every tool requisite for constructing the novel automaton, and in his assistant, Mr. Bryan Donkin, a young and zealous mechanist, who, combining precision of workmanship with fertility of invention, could turn his local advantages to the best account. To this gentleman, aided by the generous confidence of Messrs. Fourdrinier, the glory of rearing to a stately manhood the helpless bantling of M. L. Didot is entirely due. In 1803, after nearly three years of intense application, he produced a self-acting machine for making an endless web of paper, which was erected at St. Neot's under the superintendence of Mr. Gamble, and performed in such a manner as to surprise every beholder.

Since that important era Mr. Donkin has steadily devoted his whole mind and means to the progressive improvement of this admirable apparatus; and has, by the unfailing regularity, precision, promptitude, and productiveness of its work, earned for himself a place along with Watt, Wedgewood, and Arkwright, in the temple of mechanical fame.

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[*] Rapport de Jury Central, par M. Le Baron Charles Dupin, vol. ii. p. 278; Paris, 1836.

[†] See this shabby piece of diplomacy unveiled in the Minutes of Evidence taken before the Select Committee of the House of Commons on Fourdrinier's patent; May, 1837.

"*La France*," says a late official eulogist of her arts, and interpreter of her sentiments, "ne craint plus la rivalité des autres peuples pour la fabrication des divers genres de papiers et de cartons."* After this boast, one would not expect to hear him immediately confess that in 1823 his country possessed only one manufactory of the *papier continu*, containing one of the Fourdrinier machines made at London by Mr. Donkin, for M. Canson, at Vidalon-les-Annonay; that in 1827 there were only 4 of these machines in France, and that in 1834 there were not many more than a dozen. He justly observes, that "this mode, being more economical, more rapid, and more powerful, will become henceforth the only one which can be practised without loss. Then will disappear the ancient system of hand-work, which likewise involved the inconveniences, we may say dangers, resulting from combinations among the operatives. The machine-made papers possess many advantages: they can receive, so to speak, unlimited dimensions; they preserve a perfectly uniform thickness throughout all their length; they may be fabricated in every season of the year; nor do they require to be sorted, trimmed, and hung up in the drying-house, operations which occasioned great waste, amounting to no less than one defective sheet out of every five. The continuous paper at one time retained the impression of the wire-wove web on its under side; a defect from which it has been freed by a pressure apparatus of Mr. Donkin, recently imported from England by M. Delatouche."

It appears from documents presented to a committee of the House of Lords in 1807, that the Messrs. Fourdrinier had, by that time, withdrawn from their stationary business the large sum of 60,000*l.*, to further the object of their patent; so many difficulties did they encounter in bringing the machinery to its then comparatively complete state, and so little encouragement or support did they receive from the paper manufacturers throughout the kingdom.

The patentees laid a statement before the public in 1806, containing the following comparative estimate of the expense attending seven vats, and that attending a machine employed upon paper sized in the engine, performing the same quantity of work as seven vats, at the rate of 12 hours daily.

A MACHINE.

	Day.		Week.			Month.			Year.		
	s.	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*
Journeymen	3	6	2	2	0	8	8	0	109	4	0
2 Ditto	2	6	1	10	0	6	0	0	78	0	0
2 Finishers	3	6	2	2	0	8	8	0	109	4	0
2 Dry workers	3	6	2	2	0	8	8	0	109	4	0
Parters (none)											
Fire (none)											
Felting									24	0	0
Washing, ditto									5	0	0
Wire									200	0	0
1 Man, to keep in repair the mill and machine									100	0	0
Total 9			7	16	0	31	4	0	734	12	0

	£	*s.*	*d.*
Expense of 7 vats per annum (see next page) is	2,604	12	0
A machine doing 7 vats' work, is, per annum	734	12	0
Balance saved by the machine per annum	£1,870	0	0

N. B.—There are other advantages, to the amount of full 400*l.* per annum, of which manufacturers are well aware, although not taken into this calculation.

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* Rapport de Jury Central, sur les Produits de l'Industrie Française exposé en 1834, par Le Baron Charles Dupin, Membre de l'Institut, Rapporteur-général et Vice President du Jury Central; ii. 278.

SEVEN VATS.

	Day.		Week.			Month.			Year.		
	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
7 Vatmen, at	3	3	6	16	6	27	6	0	354	18	0
7 Couchers	3	1	6	9	6	25	18	0	336	14	0
7 Layers	3	1	6	9	6	25	18	0	336	14	0
3 Finishers	4	0	3	12	0	14	8	0	187	4	0
6 Dry workers	3	1	5	11	0	22	4	0	288	12	0
3 Men to go to press, &c.	2	6	2	5	0	9	0	0	117	0	0
7 Parters (women)	1	4	2	16	0	11	4	0	145	12	0
Fire			7	0	0	28	0	0	364	0	0
Felting									140	0	0
Washing ditto, oil, soap, fire, &c.			1	11	6	6	6	0	81	18	0
Moulds									140	0	0
1 Man, and expenses of repairing, in keeping in order 7 vats, vat-presses, &c.									112	0	0
Total 41 persons.			42	11	0	170	4	0	2,604	0	0

In the same statement, it was shown that the expense of making paper by hand is 16*s*. per cwt., whereas by their machine it is only 3*s*. 9*d*.; so that upon 432,000 cwts. the quantity annually made in Great Britain and Ireland (as founded upon the fact that one vat can make 480 cwts. of paper, and that there were 900 vats in the kingdom), the annual saving by the machine would be 264,600*l*., or 345,600*l*. — 81,000*l*.

In a second statement laid before the public in 1807, the patentees observe that their recently improved machine, from its greater simplicity, may be erected at a considerably reduced expense. "Mr. Donkin, the engineer, will engage to furnish machines of the dimensions specified below, with all the present improvements, at the prices specified below.

	Inches.	If driven by straps.	£
3 or 4 vats	30	between the deckles	715
6 ditto	40	ditto ditto	845
8 ditto	44	ditto ditto	940
12 ditto	54	ditto ditto	995
		If driven by wheels.	
3 or 4 vats	30	between the deckles	750
6 ditto	40	ditto ditto	880
8 ditto	44	ditto ditto	980
12 ditto	54	ditto ditto	1,040

"Instead of 5 men, formerly employed upon 1 machine, 3 are now (in 1813) fully sufficient, without requiring that degree of attention and skill which was formerly indispensable.

"In 1806 the machine was capable of doing the work of 6 vats in twelve hours; it is, however, now capable of doing double that quantity, at one fourth of the expense. For by the various improvements enumerated above, the consumption of wire is reduced nearly one half, and lasts above double the time; the quantity of paper produced is doubled; and, taking into consideration the work which is now performed by the men over and above their immediate attendance upon the machine, it may be fairly stated, that the number of men is reduced to one half; consequently the expense of wire and labor is reduced to one fourth of what it was.

"The other advantages incidental to the nature of the process of making paper by this machine, may be classed in the following order:—

"1st. That the paper is much superior in strength, firmness, and appearance, to any which can be made by hand of the same material.

"2d. It requires less drying, less pressing and parting, and consequently comes sooner to market; for it receives a much harder pressure from the machine than can possibly be given by any vat press, and is therefore not only drier, but, on account of the closeness and firmness of texture, even the moisture which remains is far sooner evaporated, on exposure to the air, than it would be from the more spongy or bibulous paper made by hand.

"The superior pressure, and the circumstance of one side of the paper passing under the polished surface of one of the pressing rollers, contribute to that smoothness which in hand-made papers can only be obtained by repeated parting and pressing; consequently a great part of the time necessarily spent in these operations is saved, and the paper sooner finished and ready for market.

"3dly. The quantity of broken paper and retree is almost nothing compared with what is made at the vats.

"4th. The machine makes paper with cold water.

"5th. It is durable, and little subject to be out of repair. The machine at Two Waters, in Hertfordshire, for the last three years, has not cost 10*l.* a year in repairs.

"6th. As paper mills are almost universally wrought by streams, which vary considerably in their power from time to time, there will result from this circumstance a very important advantage in the adoption of the machine. The common paper mill being limited by its number of vats, no advantage can be taken of the frequent accessions of power which generally happen in the course of the year; but, on the contrary, as scarcely any mills are capable of preparing stuff for twelve vats, every accession of power to the mill, where a machine is employed, will increase its produce without any additional expense.

"7th. The manufacturer can suspend or resume his work at pleasure; and he is besides effectually relieved from the perplexing difficulties and loss consequent upon the perpetual combinations for the increase of wages."

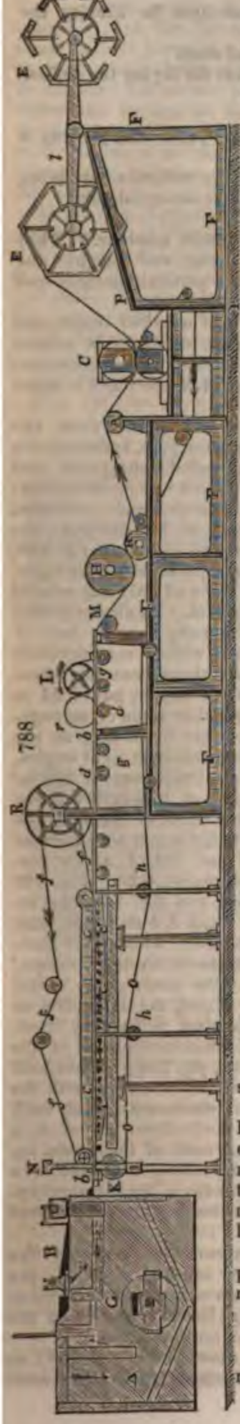
It is a lamentable fact, that the attention required to mature this valuable invention, and the large capital which it absorbed, led ultimately to the bankruptcy of this opulent and public-spirited company; after which disaster no patent dues were collected, though twelve suits in Chancery were instituted; these being mostly unsuccessful, on account of some paltry technical objections made to their well-specified patent, by that unscientific judge Lord Tenterden. The piratical tricks practised by many considerable paper-makers against the patentees are humiliating to human nature in a civilized and *soi-disant* Christian community. Many of them have owned, since the bankruptcy of the house removed the fear of prosecution, that they owed them from 2000*l.* to 3000*l.* apiece.

Nothing can place the advantage of the Fourdrinier machine in a stronger point of view, than the fact of there being 280 of them now at work in the United Kingdom, making collectively 1600 miles of paper, of from 4 to 5 feet broad, every day; that they have lowered the price of paper 50 per cent., and that they have increased the revenue, directly and indirectly, by a sum of probably 400,000*l.* per annum. The tissue paper made by the machine is particularly useful for communicating engraved impressions to pottery ware; before the introduction of which there was but a miserable substitute. Messrs. R. and J. Clewes, of Cobridge potteries, in a letter to Messrs. Fourdrinier, state, "that had not an improvement taken place in the manufacture of paper, the new style of engraving would have been of no use, as the paper previously used was of too coarse a nature to draw from the fair engravings any thing like a clear or perfect impression; and the Staffordshire potteries, in our opinion, as well as the public at large, are deeply indebted to you for the astonishing improvement that has recently taken place, both as regards china and earthenware, more particularly the latter." The following rates of prices justify the above statement:—

	1814.		1822.		1833.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
Demy pottery tissue - - - - -	12	0	9	6	7	0
Royal - - - - - - -	16	3	12	0	8	9

"We have adopted a new mode of printing on china and earthenware, which, but for your improved system of making tissue paper, must have utterly failed; our patent machine requiring the paper in such lengths as were impossible to make on the old plan. On referring to our present stock, we find we have one sheet of your paper more than 1200 yards long. Signed, Machin and Potts; Burslem, February 25th, 1834."

I have had the pleasure of visiting more than once the mechanical workshops of Messrs. Bryan Donkin and Co. in Bermondsey, and have never witnessed a more admirable assortment of exquisite and expensive tools, each adapted to perform its part with despatch and mathematical exactness, though I have seen probably the best machine factories of this country and the Continent. The man of science will appreciate this statement, and may perhaps be surprised to learn that the grand mural circle of 7 feet diameter, made by Troughton, for the Royal Observatory of Greenwich, was turned with final truth upon a noble lathe in the said establishment. It has supplied no fewer than 133 complete automatic paper machines, each of a value of from 1200*l.* to 2000*l.*, to different manufactories, not only in the United Kingdom, but in all parts of the civilized world; as mentioned in the second paragraph of the present article. Each

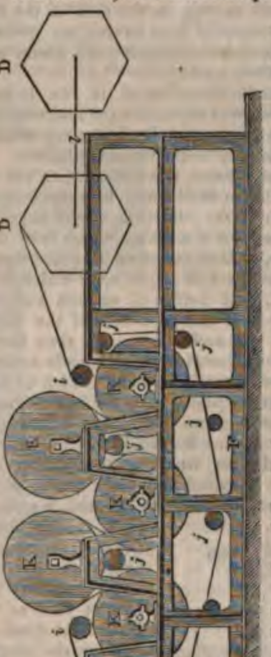


788

machine is capable of making, under the impulsion of any prime mover, all unwatched by a human eye, and unguided by a human hand, from 20 to 50 feet in length, by 5 feet broad, of most equable paper in one minute. Of paper of average thickness, it turns off 30 feet.

Fig. 788 is an upright longitudinal section, representing the machine in its most complete state, including the drying steam cylinders, and the compound channelled rollers of Mr. Wilks, subsequently to be described in detail. The figure in the upper line shows it all in train, when the paper is to be wound up wet upon the reels E, E, which being moveable round the centre *l* of a swing-bar, are presented empty, time about, to receive the tender web. The figure in the under line contains the steam or drying cylinders; the points O O, of whose frame, replace, at the points P, P, the wet reel frame, F F, P.

A is the vat, or receiver of pulp from the stuff-chest.



B is the knot strainer of Ibotson (p. 967), to clear the pulp before passing on to the wire.

G is the hog, or agitator in the vat. The arrows show the course of the currents of the pulp in the vat.

I is the apron, or receiver of the water and pulp which escape through the endless wire, and which are returned by a scoop-wheel into the vat.

b is the copper lip of the vat, over which the pulp flows to the endless wire, on a leathern apron extending from this lip to about nine inches over the wire, to support the pulp and prevent its escaping.

c, *c* are the bars which bear up the small tube rollers that support the wire.

d, *d* are ruler bars to support the copper rollers over which the wire revolves.

K is the breast roller, round which the endless wire turns.

N is the point where the shaking motion is given to the machine.

M is the guide roller, having its pivots moveable laterally to adjust the wire and keep it parallel.

L is the pulp roller, or, "dandy," to press out water, and to set the paper. *r*, is the place of the second, when it is used.

H is the first or wet press, or couching rollers; the wire leaves the paper here, which latter is couched upon the endless felt *p*; and the endless wire *o* returns, passing round the lower couch roller. By Mr. Donkin's happy invention of placing these rollers obliquely, the water runs freely away, which it did not do when their axes were in a vertical line.

e, *e* are the deckles, which form the edges of the sheet of paper, and prevent the pulp passing away laterally. They regulate the width of the endless sheet.

f, *f* are the revolving deckle straps.

R is the deckle guide, or driving-pulley.

g, *g* are tube rollers, over which the wire passes, which do not partake of the shaking motion; and, *h, h* are moveable rollers for stretching the wire, or brass carriages for keeping the rollers *g, g* in a proper position.

C is the second press, or dry press, to expel the water in a cold state.

K, K, &c., in the view of the lower line, are the steam cylinders for drying the endless sheet.

i, i are rollers to convey the paper.

j, j are rollers to conduct the felt; which serves to support the paper, and prevent it wrinkling or becoming cockled.

D, D are the hexagonal expanding reels for the steam-dried paper web, one only being used at a time, and made to suit different sizes of sheets. *l* is their swing fulcrum.

F, F, F, F, is the frame of the machine.

The deckle straps are worthy of particular notice in this beautiful machine. They are composed of many layers of cotton tape, each one inch broad, and together one half inch thick, cemented with caoutchouc, so as to be at once perfectly flexible and water-tight.

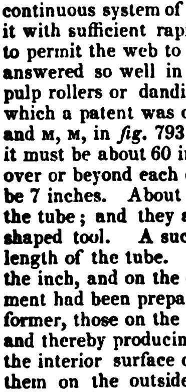
The upper end of each of the two carriages of the roller L is of a forked shape, and the pivots of the roller are made to turn in the cleft of the forked carriages in such a manner, that the roller may be prevented from having any lateral motion, while it possesses a free vibratory motion upwards and downwards; the whole weight of the roller L being borne by the endless web of woven wire.'

The greatest difficulty formerly experienced in the paper manufacture upon the continuous system of Fourdrinier, was to remove the moisture from the pulp, and condense it with sufficient rapidity, so as to prevent its becoming what is called *water-galled*, and to permit the web to proceed directly to the drying cylinders. Hitherto no invention has answered so well in practice to remove this difficulty as the channelled and perforated pulp rollers or dandies of Mr. John Wilks, the ingenious partner of Mr. Donkin; for which a patent was obtained in 1830. Suppose one of these rollers (see L, in *fig.* 788, and M, M, in *fig.* 793) is required for a machine which is to make paper 54 inches wide, it must be about 60 inches long, so that its extremities (see *figs.* 789 and 790) may extend over or beyond each edge of the sheet of paper upon which it is laid. Its diameter may be 7 inches. About 8 grooves, each 1-16th of an inch wide, are made in every inch of the tube; and they are cut to half the thickness of the copper, with a rectangularly shaped tool. A succession of ribs and grooves are thus formed throughout the whole length of the tube. A similar succession is then made across the former, but of 24 in the inch, and on the opposite surface of the metal, which by a peculiar mode of management had been prepared for that purpose. As the latter grooves are cut as deep as the former, those on the inside meet those on the outside, crossing each other at right angles, and thereby producing so many square holes; leaving a series of straight copper ribs on the interior surface of the said tube, traversed by another series of ribs coiled round them on the outside, forming a cylindrical sieve made of one piece of metal. The rough edges of all the ribs must be rounded off with a smooth file into a semi-circular form. *Figs.* 789 and 790, A A, are portions of the ribbed copper tube. *Fig.* 789 shows the exterior, and *fig.* 790 the interior surface; *b, b* and *b, b* show the plain part at each of the ends, where it is made fast to the brass rings by rivets or screws; C, C are the rings with arms, and a centre piece in each, for fixing the iron pivot or shaft B; one such pivot is fixed by riveting it in each of the centre pieces of the rings, as shown at *c*, *fig.* 790; so that both the said pieces shall be concentric with the rings, and have one common axis with each other, and with the roller. At *a, a*, a groove is turned in each of the pivots, for the purpose of suspending a weight by a hook, in order to increase the pressure upon the paper, whenever it may be found necessary.

Fig. 791 is an end view, showing the copper tube and its internal ribs A, A; the brass rings C, C; arm D, D, D; centre piece E, and pivot B. *Fig.* 792 is a section of the said ring, with the arms, &c.

The roller is shown at L, *fig.* 788, as lying upon the surface of the wire-web.

790



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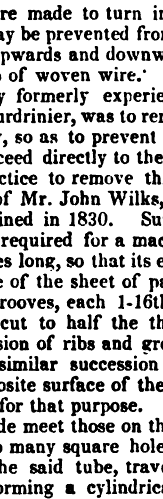

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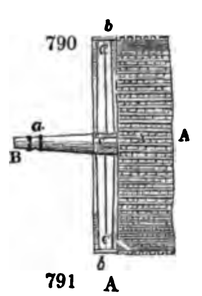

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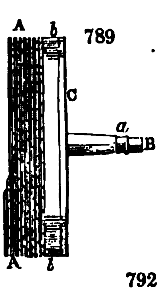


ıtive position of that perforated roller, and the little roller *b*, over which such that the axis of L is a little to one side of the axis of *b*, and not in the tical plane, the latter being about an inch nearer the vat end. Hence, when-wire-web is set in progressive motion, it will cause the roller L to revolve upon :e; and as the paper is progressively made, it will pass onwards with the web ıe surface of the roller. Thus the pulpy layer of paper is condensed by ;ion under the ribbed roller; while it transmits its moisture through the ons, it becomes sufficiently compact to endure the action of the wet press , H, and also acquires the appearance of parallel lines, as if made by hand in a fd.

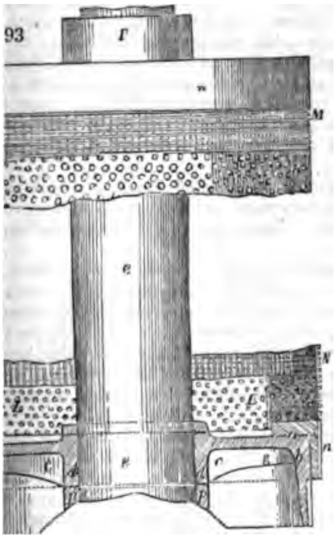
'ilks occasionally employs a second perforated roller in the same paper machine, then placed at the dotted lines *i*, *i*, *i*.

atentee has described in the same specification a most ingenious modification of roller, by which he can exhaust the air from a hollowed portion of its periphery, e the paper in its passage over the roller to undergo the sucking operation of ial void, so as to be remarkably condensed; but he has not been called upon to s second invention, in consequence of the perfect success which he has experi- the working of the first.

ıllowing is a more detailed illustration of Mr. Wilks' improved roller.

93 represents two parts of his double-cased exhausting cylinder.

93



This consists of two copper tubes, one nicely lining the other; the inner being punched full of round holes, as at K, K, where that tube is shown uncovered; a portion of the inner surface of the same tube is shown at L, L. In this figure also, two portions of the outer tube are shown at M, M, and N, N; the former being an external, and the latter an internal view. Here we see that the external tube is the ribbed perforated one already described; the holes in the inner tube being made in rows to correspond with the grooves in the outer. The holes are so distributed that every hole in one row shall be opposite to the middle of the space left between two holes in the next row, as will appear from inspection of the figure. The diameter of each of the punched holes somewhat exceeds the width of each rib in the inside of the outer cylinder, and every inside groove of this tube coincides with a row of holes in the former, which construction permits the free transudation or perco ; the water out of the pulp. At each end of this double-case cylinder, a part is N, N, plain without, and grooved merely in the inside of the outer tube. The surface allows the brass ends to be securely fixed; the outer edge of the brass tight into the inside of the end of the cylinders.

e inside of each of these rings there are four pieces which project towards the ɔr axis of the cylinder; two of which pieces are shown at *a*, *a*, *fig.* 793, in *b*, *b*, is a brass ring with four arms *c*, *c*, *c*, *c*, and a boss or centre piece *d*, *d*. ter edge of the last-mentioned ring is also turned cylindrical, and of such a r as to fit the interior of the former ring *o*, *o*. The two rings are securely ;ether by four screws. *e*, *e* is the hollow iron axle or shaft upon which the revolves. Its outside is made truly cylindrical, so as to fit the circular holes bosses *d*, *d*, of the rings and arms at each end of the cylinder. Hence, if the shaft be so fixed that it will not turn, the perforated cylinder is capable of having ry motion given to it round that shaft. This motion is had recourse to, when the apparatus is employed. But otherwise the cylinder is made fast to the hollow means of two screw clamps. To one end of the cylinder, as at *p*, a toothed wheel ıed, for communicating a rotatory motion to it, so that its surface motion shall be e as that of the paper web; otherwise a rubbing motion might ensue, which would ıd injure both.

ɔaper stuff or pulp is allowed to flow from the vat A, *fig.* 788, on to the surface of less wire-web, as this is moving along. The lines *o*, *o*, *fig.* 788, show the course of the motion of the web, which operates as a sieve, separating to a certain degree the water from the pulp, yet leaving the latter in a wet state till it arrives at the first pair of pressing rollers H, H, between which the web with its sheet of paper is squeezed. Thick paper, in passing through these rollers, was formerly often injured by becoming water-galled, from the greater retention of water in certain places than in others. But Messrs. Donkin's cylinder, as above described, has facilitated vastly the discharge of the water, and enabled the manufacturer to turn off a perfectly uniform smooth paper.

In *fig.* 788, immediately below the perforated cylinder, there is a wooden water-trough. Along one side of the trough a copper pipe is laid, of the same length as the cylinder, and parallel to it; the distance between them being about one fourth of an inch. The side of the pipe facing the cylinder is perforated with a line of small holes, which transmit a great many jets of water against the surface of the cylinder, in order to wash it and keep it clean during the whole continuance of the process.

The principle adopted by John Dickinson, Esq., of Nash Mill, for making paper, is different from that of Fourdrinier It consists in causing a polished hollow brass cylinder, perforated with holes or slits, and covered with wire cloth, to revolve over and just in contact with the prepared pulp: so that by connecting the cylinder with a vessel exhausted of its air, the film of pulp, which adheres to the cylinder during its rotation, becomes gently pressed, whereby the paper is supposed to be rendered drier, and of more uniform thickness, than upon the horizontal hand moulds, or travelling wire cloth of Fourdrinier. When subjected merely to agitation, the water is sucked inwards through the cylindric cage, leaving the textile filaments so completely interwoven as, if felted among each other, that they will not separate without breaking, and, when dry, they will form a sheet of paper of a strength and quality relative to the nature and preparation of the pulp. The roll of paper thus formed upon the hollow cylinder is turned off continuously upon a second solid one covered with felt, upon which it is condensed by the pressure of a third revolving cylinder, and is thence delivered to the drying rollers.

Such is the general plan of Mr. Dickinson's paper machines, into which he has introduced numerous improvements since its invention in 1809, many of them secured by patent right; whereby he has been enabled to make papers of first-rate quality, more particularly for the printing-press. See *infrà*.

In July, 1830, Mr. Ibotson of Poyle, paper manufacturer, obtained a patent, see B, *fig.* 788, which has proved very successful, for a peculiar construction of a sieve or strainer. Instead of wire meshes, he uses a series of bars of gun-metal, laid in the bottom of a box, very closely together, so that the upper surfaces or the flat sides may be in the same plane, the edge of each bar being parallel with its neighbor, leaving parallel slits between them of from about 1-70th to 1-100th of an inch in width, according to the fineness or coarseness of the paper-stuff to be strained. As this stuff is known to consist of an assemblage of very fine flexible fibres of hemp, flax, cotton, &c., mixed with water, and as, even in the pulp of which the best paper is made, the length of the said fibres considerably exceeds the diameter of the meshes of which common strainers are formed, consequently the longest and most useful fibres were formerly lost to the paper manufacturer. Mr. Ibotson's improved sieve is employed to strain the paper-stuff previously to its being used in the machine above described, (see its place at B in the vat.) When the strainer is at work, a quick vertical and lateral jogging motion is given to it. by machinery similar to the jogging screens of corn mills.

Since the lateral shaking motion of the wire-web in the Fourdrinier machine, as originally made, was injurious to the fabric of the paper, by bringing its fibres more closely together breadthwise than lengthwise, thus tending to produce long ribs, or thick streaks in its substance, Mr. George Dickinson, of Buckland Mill, near Dover, proposed, in the specification of a patent obtained in February, 1828, to give a rapid up-and-down movement to the travelling web of pulp. He does not, however, define with much precision any proper mechanism for effecting this purpose, but claims every plan which may answer this end. He proposes generally to mount the rollers, which conduct the horizontal endless web, upon a vibrating frame. The forepart of this frame is attached to the standards of the machine, by hinge joints, and the hinder part, or that upon which the pulp is first poured out, is supported by vertical rods, connected with a crank on a shaft below. Rapid rotatory motion being given to this crank-shaft, the hinder part of the frame necessarily receives a quick up-and-down vibratory movement, which causes the water to be shaken out from the web of pulp, and thus sets the fibres of the paper with much greater equality than in the machines formerly constructed. A plan similar to this was long ago introduced into Mr. Donkin's machines, in which the vibrations were actuated in a much more mechanical way.

John Dickinson, Esq., of Nash Mill, obtained a patent in October, 1830, for a method of uniting face to face two sheets of pulp by means of machinery, in order to produce paper of extraordinary thickness. Two vats are to be supplied with paper stuff as usual; in which two hollow barrels or drums are made to revolve upon axles driven by any first mover; an endless felt is conducted by guide rollers, and brought into contact with the drums; the first drum gives off the sheet of paper pulp from its periphery to the felt, which passing over a pressing roller, is conducted by the felt to that part of a second drum which is in contact with another pressing roller. A similar sheet of paper pulp is now given off from the second drum, and it is brought into contact with the former by the pressure of its own roller. The two sheets of paper pulp thus united are carried forward by the felt over a guide roller, and onward to a pair of pressing rollers, where by contact the moist surfaces of the pulp are made to adhere, and to constitute one double thick sheet of paper, which, after passing over the surfaces of hollow drums, heated by steam, becomes dry and compact. The rotatory movements of the two pulp-lifting drums must obviously be simultaneous, but that of the pressing rollers should be a little faster, because the sheets extend by the pressure, and they should be drawn forward as fast as they are delivered, otherwise creases would be formed. Upon this invention is founded Mr. Dickinson's ingenious method of making safety-paper for Post-office stamps, by introducing silk fibres, &c., between the two laminæ.

The following contrivance of the same inventive manufacturer is a peculiarly elegant mechanical arrangement, and is likely to conduce to the perfection of machine-made paper. I have already described Mr. Ibotson's excellent plan of parallel slits, or gridiron strainers, which has been found to form paper of superior quality, because it permits all the elongated tenacious fibres to pass, which give strength to the paper, while it intercepts the coarser knots and lumps of the paste, that were apt to spoil its surface. Mr. Turner's circular wire sieves, presently to be noticed, may do good work, but they cannot compete with Mr. Dickinson's present invention, which consists in causing the diluted paper pulp to pass between longitudinal apertures, about the hundred-and-fifteenth part of an inch wide, upon the surface of a revolving cylinder.

The pulp being diluted to a consistency suitable for the paper machine, is delivered into a vat, of which the level is regulated by a waste pipe, so as to keep it nearly full. From this vat there is no other outlet for the pulp, except through the wire-work periphery of the revolving cylinder, and thence out of each of its ends into troughs placed alongside, from which it is conducted to the machine destined to convert it into a paper web.

The revolving cylinder is constructed somewhat like a squirrel cage, of circular rods, or an endless spiral wire, strengthened by transverse metallic bars, and so formed that the spaces between the rings are sufficient to allow the slender fibres of the pulp to pass through, but are narrow enough to intercept the knots and other coarse impurities, which must of course remain, and accumulate in the vat. The spaces between the wires of the squirrel cage may vary from the interval above stated, which is intended for the finest paper, to double the distance for the coarser kinds.

It has been stated that the pulp enters the revolving cylinders solely through the intervals of the wires in the circumference of the cylinder; these wires or rods are about three eighths of an inch broad without, and two eighths within, so that the circular slits diverge internally. The rods are one quarter of an inch thick, and are riveted to the transverse bars in each quadrant of their revolution, as well as at their ends to the necks of the cylinder.

During the rotation of the cylinder, its interstices would soon get clogged with the pulp, were not a contrivance introduced for creating a continual vertical agitation in the inside of the cylinder. This is effected by the up-and-down motion of an interior agitator or plunger, nearly long enough to reach from the one end of the cylinder to the other, made of stout copper, and hollow, but water-tight. A metal bar passes through it, to whose projecting arm at each end a strong link is fixed; by these two links it is hung to two levers, in such a way that when the levers move up and down, they raise and depress the agitator, but they can never make it strike the sides of the cylinder. Being heavier than its own bulk of water, the agitator, after being lifted by the levers, sinks suddenly afterwards by its weight alone.

The agitator's range of up-and-down movement should be about one inch and a quarter, and the number of its vibrations about 80 or 100 per minute; the flow of the pulp through the apertures is suddenly checked in its descent and promoted in its ascent, with the effect of counteracting obstructions between the ribs of the cylinder.

The sieve cylinder has a toothed wheel fixed upon the tubular part of one of its ends, which works between two metal flanches made fast to the wooden side of the vat, for the purpose of keeping the pulp away from the wheel; and it is made to revolve by a pinion fixed on a spindle, which going across the vat, is secured by two plummer blocks on the outside of the troughs, and has a rotatory motion given to it by an outside rigger or pulley, by means of a strap from the driving shaft, at the rate of 40 or 50 revolutions per minute. This spindle has also two double eccentrics fixed upon it, immediately under the levers, so that in every revolution it lifts those levers twice, and at the same time lifts the agitator.

The diameter of the sieve cylinder is not very material, but 14 inches have been found a convenient size; its length must be regulated according to the magnitude of the machine which it is destined to supply with pulp. One, four feet long in the cage part, is sufficient to supply a machine of the largest size in ordinary use, viz., one capable of making paper 4 feet 6 inches wide. When the cylinder is of this length, it should have a wheel and pinion at each end.

Metal flanches are firmly fixed to the sides of the vat, with a water-tight joint, and form the bearings in which the cylinder works.

Mr. Turner of Bermondsey, paper-maker, obtained a patent in March, 1831, for a peculiar strainer, designed to arrest the lumps mixed with the finer paper pulp, whereby he can dispense with the usual vat and hog in which the pulp is agitated immediately before it is floated upon the endless wire-web of the Fourdrinier apparatus. His strainer may also be applied advantageously to hand paper machines. He constructs his sieves of a circular form, by combining any desirable number of concentric rings of metal, with small openings between them, from the 50th to the 100th part of an inch wide. In order to facilitate the passage of the fine pulp and water, the sieves receive a vibratory motion up and down, which supersedes the hog employed in other paper-making machines.

A mechanism to serve the same purpose as the preceding, in which Mr. Ibotson's plan of a parallel rod-strainer is modified, was made the subject of a patent by Mr. Henry Brewer, of Surrey Place, Southwark, in March, 1832. He constructs square boxes with gridiron bottoms, and gives a powerful up-and-down vibration in the pulp tub, by levers, rotatory shafts, and cranks.

As the contrivance is not deficient in ingenuity, and may be useful, I shall describe this mode of adapting his improved strainers to a vat in which paper is to be made by hand moulds. A hog (or churning rotator) is employed for the purpose of agitating the pulp at the bottom of the vat, in which the sieve is suspended from a crank-shaft, or in any other way, so as to receive the up-and-down vibratory motion for the purpose of straining the pulp. The pulp may be supplied from a chest, and passed through a cock into a trough, by which it is conveyed to the strainers.

A pipe from the bottom of the vat leads into a lifter-box, which is designed to convey thin pulp into the sieve, in order to dilute that which is delivered from the chest. This pipe also allows the small lumps, called rolls, to be re-sifted. The pressure of the pulp and water in the vat forces the pulp up the pipe into the lifter-box, whence it is taken by rotatory lifters, and discharged into a trough, where it runs down and mixes with the thick pulp from the chest, as before mentioned. By these means the contents of the vat are completely strained or sifted over again in the course of almost every hour.

A patent was obtained for a paper-pulp strainer by Mr. Joseph Amies, of Loose, in the county of Kent, paper manufacturer, who makes the bottoms of his improved strainers with plates of brass or other suitable metal, and forms the apertures for the fine fibres of pulp to pass through, by cutting short slits through such plates, taking care that as much metal is left between the ends of each short slit and the next following as will properly brace or stiffen the ribs of the strainer; and he prefers that the end of one slit shall be nearly opposite to the middle of the two slits next adjoining it, which is commonly called blocking the joints. This is for giving rigidity to the bottom of the strainer, and constitutes the main feature of his improvement. The bottoms of sieves previously constructed with long metallic rods, he considers to be liable to lateral vibration in use, and thus to have permitted knots and lumps to pass through their expanded intervals. This objection is not applicable to Mr. Dickinson's squirrel-cage strainer, of which the ribs may be made rigid by a sufficient number of transverse bars; nor in fact is it applicable to Mr. Ibotson's original strainer, as it is admirably constructed by Messrs. Donkin and Co. Each bar which they make being inflexible by a feathered rib, is rendered perfectly straight in its edge by grinding with emery upon a flat disc-wheel of block tin, and of invariable length, by a most ingenious method of turning each set of bars in a lathe. The bars are afterwards adjusted in the metallic sieve-frame, or chest, at any desired distance apart, from the 120th to the 60th of an inch, in such a manner as secures them from all risk of derangement by the vibratory or jogging motion in shaking the pulpy fibres through the lineal intervals between them.

Mr. James Brown, paper manufacturer, of Esk mills, near Edinburgh, obtained a patent in May, 1836, for a particular mode of applying suction to the pasty web in the Fourdrinier's machine. He places a rectangular box transversely beneath the horizontal wire cloth, without the interposition of any perforated covering, such as had been tried in the previously constructed vacuum machines, and which he considers to have impeded their efficacy in condensing the pulp and extracting the water.

Upon this and all similar contrivances for making a partial vacuum under the pulpy paper web, it may be justly remarked, that they are more apt to injure than improve the texture of the article; since when the suction is unequally operative, it draws down not only the moisture, but many of the vegetable fibres, causing roughnesses, and even numerous small perforations in the paper.

A modification of Mr. Dickinson's cylinder-mould continuous paper machine was made the subject of a patent in Nov. 1830, by Mr. John Hall, jun., of Dartford, as communicated to him by a foreigner residing abroad. The leading feature of the invention is a mode of supplying the vat in which the wire cylinder is immersed with a copious flow of water, for the purpose of creating a considerable pressure upon the external surface of the cylinder, and thereby causing the fibres of the paper pulp to adhere to the mould.

There is a semi-cylindrical trough, in which the mould is immersed, and made to revolve by any convenient means. The pulp is transferred from the vat into that vessel at its bottom part. On the side of the drum-mould opposite to the vat, there is a cistern into which a copious flow of water is delivered, which passes thence into the semi-cylindrical trough. In the interior of the cylindrical mould, a bent or syphon tube is introduced, on the horizontal part of which tube, inside, the mould revolves. This tube is connected at the outside to a pump, by which the water is drawn from the interior of the cylindrical mould. Thus the water in the semi-cylindrical trough, on the outside of the drum, is kept at a considerably higher level than it is within; and consequently the pressure of the water, as it passes through the wire gauze, will, it is supposed, cause the fibres of the paper pulp to adhere to the circumference of the mould. The water which is withdrawn from the interior of the drum by the recurved tube, is conducted round into the cistern, where its discharge is impeded by several vertical partitions, which make the water flow in a gentle stream into the semi-cylindrical mould vat. In order to keep the pulp properly agitated in the mould vat, a segment frame, having rails extended across the vat, is moved to and fro; as the drum mould goes round, the fibres of the pulp are forced against its circumference, and as the water passes through, the fibres adhere, forming the sheet of paper, which, on arriving at a couching roller above, is taken up as usual by an endless felt, conducted away to the drying apparatus, and thence to the reel to be wound up.

The patentee claims merely the application of a pump to draw the water from the interior of the mould drum, and to throw it upon its external surface.

A rag-cutting and lacerating machine was patented by Mr. Henry Davy, of Camberwell, in September, 1833, being a communication from a foreigner residing abroad. The machine consists of an endless feeding-cloth, by which the rough rags supplied by the attendants are progressively conducted forwards to a pair of feed-rollers (see COTTON, *spinning*), and on passing through these rollers, the rags are subjected to the operation of rotatory cutters, acting against a fixed or ledger blade, which cut and tear them to pieces. Thence the rags pass down an inclined sieve, upon which they are agitated to separate the dust. The cleaned fragments are delivered on to a horizontal screen or sorting table, to suffer examination. When picked here, they are ready for the pulp-engine. A distinct representation of this machine is given in Newton's Journal, conjoined series, vol. iv. pl. ix. *fig.* 1.

Mr. Jean Jacques Jequier obtained a patent in August, 1831, for a mode of making paper on the continuous machine with wire-marks. The proposed improvement consists merely in the introduction of a felted pressing roller, to act upon the paper after it has been discharged from the mould, and need not therefore be particularly described.

In August, 1830, Mr. Thomas Barratt, paper-maker, of St. Mary Cray, in the county of Kent, obtained a patent for an apparatus by which paper may be manufactured in a continuous sheet, with the water-mark and maker's name, so as to resemble in every respect paper made by hand, in moulds the size of each separate sheet. On the wire web, at equal distances apart, repetitions of the maker's name or other device is placed, according to the size of the paper when cut up into single sheets. In manufacturing such paper, the ordinary method of winding upon a reel cannot be employed; and therefore the patentee has contrived a compensating reel, whose diameter diminishes at each revolution, equal to the thickness of a sheet of paper. See Newton's Journal, C. S. vol. vii. p. 285.

For Mr. Lemuel Wellman Wright's series of improvements in the manufacture of paper, specified in his patent of November, 1834, I must refer to the above Journal, C. S., vol. viii. p. 86.

A committee of the *Société d'Encouragement*, of Paris, made researches upon the best composition for sizing paper in the vat, and gave the following recipe:—

100 kilogrammes of dry paper stuff.
12 — starch.
1 — rosin, previously dissolved in 500 grammes of carbonate of soda.
18 pails of water.

M. Braconnot proposed the following formula in the 23d volume of the *Annales de Chimie et de Physique*:—To 100 parts of dry stuff, properly diffused through water, add a boiling uniform solution of 8 parts of flour, with as much caustic potash as will render the liquor clear. Add to it one part of white soap previously dissolved in hot water. At the same time heat half a part of rosin with the requisite quantity of weak potash ley for dissolving the rosin; mix both solutions together, and pour into them one part of alum dissolved in a little water.

Those who color prints, size them previously with the following composition:—4 ounces of glue, and 4 ounces of white soap dissolved in 3 English pints of hot water. When the solution is complete, two ounces of pounded alum must be added, and as soon as the composition is made homogeneous by stirring, it is ready for use. It is applied cold with a sponge, or rather with a flat camel's hair brush. Ackermann's liquor, as analyzed by Vauquelin, may be made for sizing paper as follows:—

100 kilogrammes of dry stuff.
4 — glue.
8 — resinous soap.
8 — alum.

The soap is made from 4·8 kilos. of pounded rosin, and 2·22 crystals of carbonate of soda, dissolved in 100 litres of water. It is then boiled till the mixture becomes quite uniform; the glue, previously softened by 12 hours' maceration in cold water, is to be next added; and when this is totally dissolved, the solution of alum in hot water is poured in. Three quarts of this size were introduced into the vat with the stuff, and well mixed with it. The paper manufactured with this paste seemed to be of excellent quality, and well sized.

The Chinese, in manufacturing paper, sometimes employ linen rags, as we do; at other times, the fibres of the young bamboo; of the mulberry; the envelope of the silk-worm cocoon; also a tree, unknown to our botanists, which the natives call *chu* or *ko-chu*; cotton down, and especially the cotton tree. The processes pursued in China to make paper with the inner bark of their *paper-tree* (*Broussonetia-papyrifera*), or Chinese mulberry, have been described at great length in the bulletin of the Société d' Encouragement, for 1826, p. 226; but they will hardly prove serviceable to a European manufacturer. That tree has been acclimated in France.

Chinese paper is not so well made as the good paper of Europe; it is not so white, it is thinner, and more brittle, but extremely soft and silky. The longitudinal tenacity of its filaments, however, renders it fitter for the engraver than our best paper. The Chinese, after triturating, grinding, and boiling the bamboo, set the paste to ferment in a heap covered with mats. Chinese paper is readily recognised, because it is smooth on one side, and bears on the other the marks of the brush with which it is finished, upon smooth tables, in order to dry it flat. The kind employed for engravings is in sheets four feet long, and two broad. It is made of the bamboo; their myrtle-tree paper would be too strong for this purpose.

Tracing paper.

The best paper of this kind, sometimes superfluously called vegetable paper, is made of the refuse of the flax mills, and prepared by the engine without fermentation. It thus forms a semi-transparent paste, and affords a transparent paper. Bank-note paper is made of the same materials, but they always undergo a bleaching with chloride of lime. Great nicety is required in drying this kind of paper. For this purpose, each sheet must be put between two sheets of gray paper in the press; and this gray paper must be renewed several times, to prevent the bank-note paper from creasing.

Paper of Safety or Surety; Papier de Sureté.

This subject has occupied the attention of the French Academy for many years, in consequence of the number of frauds committed upon the stamp revenue in France. One of the best methods of making a paper which would evince whether any part of a writing traced upon it had been tampered with or discharged, is to mix in the vat two kinds of pulp, the one perfectly white, the other dyed of any color easily affected by chlorine, acids, and alkalis. The latter stuff being mingled with the former in any desired proportion, will furnish a material for making a paper which will contain colored points distributed throughout all its substance, ready to show, by the changes they suffer, whether any chemical reaction has been employed.

Quantity of Paper charged with Duties of Excise, in the United Kingdom, in

	1834.			1835.			1836.		
	lbs.			*lbs.*			*lbs.*		
First class - - - -	54,053,721			56,179,555			66,202,689		
Second class - - -	16,552,168			17,863,095			15,906,258		
Pasteboard, millboard, &c. -	49,392			49,772			36,340		
	yards.			*yards.*			*yards.*		
Stained - - - -	8,749,144			8,247,931			8,032,577		
	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*
Amount of duty, first class -	675,671	10	0	702,244	9	0	651,699	0	0
— second class	103,451	0	0	111,644	0	0	99,414	0	0
— pasteboard, &c.	54,689	0	0	54,548	15	0	39,557	0	0
— stained -	63,795	16	0	60,141	0	0	22,112	0	0

The late reduction of the duty, from 3d. to 1½d. per lb., upon paper of the first class, viz., on all descriptions of it, except that made out of tarred ropes only, has been already attended with considerable benefit to the manufacture, and would have acted with much greater effect, but for the American crisis. The gross amount of the paper duty in the year ending 5th January, 1836, was 831,057*l.*, and in the year ending 5th January, 1838, it was 554,497*l.*; instead of being little more than one half, as might have been the case from the reduction of the duty, which only came into full operation in the year 1837. At the same time that the tax on common paper was reduced, that upon stained paper was repealed altogether. The effect of the diminution consequently made in the price of paper-hangings, has been so great as nearly to double the consumption of the country, while the manufacture appears to be still rapidly on the increase.

Declared Value of Stationary and Printed Books exported in

Years.	Stationary.	Printed Books.	Total.
1827	£195,110	£107,199	£302,309
1828	208,532	102,874	311,406
1829	190,652	109,878	300,530
1830	171,848	95,874	267,722
1831	179,216	101,110	280,326
1832	177,718	93,038	270,756
1833	211,518	124,535	336,053
1834	211,459	122,595	334,054
1835	259,105	148,318	407,423
1836	301,121	178,945	480,066

Till the paper trade shall escape entirely from the clutches of its ancient dry-nurse, the excise, neither it nor the book trade can acquire the same ascendency in exportation which all other articles of British manufactures have over the French.

The value of Stationary exported in France, from 1833, was—

Cartons lustrés (polished pasteboards for the cloth manufacture)	18,992 francs.
Cartons en feuilles (pasteboard in sheets) - - - -	6,352 —
Cartons moulés (papier-maché) - - - - - -	215,376 —
Cartons coupés et assemblés - - - - - - -	54,184 —
Wrapping paper - - - - - - - - - -	178,544 —
White paper, and rayé (ruled) pour musique - - -	2,903,075 —
Colored paper in reams - - - - - - - -	58,541 —
Stained paper (paper hangings) in *rouleaux*, - - - -	1,885,387 —
Silk paper - - - - - - - - - -	3,240 —
Total (=£208,000)	5,323,621 francs.

PARAFFINE. Distil beech-tar to dryness, rectify the heavy oil which collects at the bottom of the receiver, and when a thick matter begins to rise, set aside what is distilled, and urge the heat moderately as long as any thing more distils. Pyrélaine passes over, containing crystalline scales of paraffine. This mixture being digested with its own volume of alcohol of 0·833, forms a limpid solution, which is to be gradually diluted with more alcohol, till its bulk becomes 6 or 8 times greater. The alcohol, which at first dissolves the whole, lets the paraffine gradually fall. The precipitate being washed with cold alcohol till it becomes nearly colorless, and then dissolved in boiling alcohol, is deposited on cooling in minute spangles and needles of pure paraffine.

Or the above mixture may be mixed with from $\frac{1}{4}$ to $\frac{1}{3}$ its weight of concentrated sulphuric acid, and subjected for 12 hours to digestion, at a heat of 150° F., till, on cooling, crystals of paraffine appear upon the surface. These are to be washed with water, dissolved in hot alcohol, and crystallized. Paraffine is a white substance, void of taste and smell, feels soft between the fingers, has a specific gravity of 0·87, melts at 112° Fahr., boils at a higher temperature with the exhalation of white fumes, is not decomposed by dry distillation, burns with a clear white flame without smoke or residuum, does not stain paper, and consists of 85·22 carbon, and 14·78 hydrogen; having the same composition as olefiant gas. It is decomposed neither by chlorine, strong acids, alkalis, nor potassium; and unites by fusion with sulphur, phosphorus, wax, and rosin. It dissolves readily in warm fat oils, in cold essential oils, in ether, but sparingly in boiling absolute alcohol. Paraffine is a singular solid bicarburet of hydrogen; it has not hitherto been applied to any use, but it would form admirable candles.

PARCHMENT. (*Parchemin*, Fr.; *Pergament*, Germ.) This writing material has been known since the earliest times, but is now made in a very superior manner to what it was anciently, as we may judge by inspection of the old vellum and parchment manuscripts. The art of making parchment consists in certain manipulations necessary to prepare the skins of animals of such thinness, flexibility, and firmness, as may be required for the different uses to which this substance is applied. Though the skins of all animals might be converted into writing materials, only those of the sheep or the she-goat are used for parchment; those of calves, kids, and dead-born lambs for vellum; those of the he-goat, she-goat, and wolves for drum-heads; and those of the ass for battledoors. All these skins are prepared in the same way, with slight variations, which need no particular detail.

They are first of all prepared by the leather-dresser. After they are taken out of the lime-pit, shaved, and well washed, they must be set to dry in such a way as to prevent their puckering, and to render them easily worked. The small manufacturers make use of hoops for this purpose, but the greater employ a *herse*, or stout wooden frame. This is formed of two uprights and two cross-bars solidly joined together by tenons and mortises, so as to form a strong piece of carpentry, which is to be fixed up against a wall. These four bars are perforated all over with a series of holes, of such dimensions as to receive slightly tapered box-wood pins, truly turned, or even iron bolts. Each of these pins is transpierced with a hole like the pin of a violin, by means of which the strings employed in stretching the skin may be tightened. Above the *herse*, a shelf is placed, for receiving the tools which the workman needs to have always at hand. In order to stretch the skin upon the frame, larger or smaller skewers are employed, according as a greater or smaller piece of it is to be laid hold of. Six holes are made in a straight line to receive the larger, and four to receive the smaller skewers or pins. These small slits are made with a tool like a carpenter's chisel, and of the exact size to admit the skewer. The string round the skewer is affixed to one of the bolts in the frame, which are turned round by means of a key, like that by which pianos and harps are tuned. The skewer is threaded through the skin in a state of tension.

Every thing being thus prepared, and the skin being well softened, the workman stretches it powerfully by means of the skewers; he attaches the cords to the skewers, and fixes their ends to the iron pegs or pins. He then stretches the skin, first with his hand applied to the pins, and afterwards with the key. Great care must be taken that no wrinkles are formed. The skin is usually stretched more in length than in breadth, from the custom of the trade; though extension in breadth would be preferable, in order to reduce the thickness of the part opposite the backbone.

The workman now takes the fleshing tool represented under CURRYING. It is a semicircular double-edged knife, made fast into a double wooden handle. Other forms of the fleshing-knife edge are also used. They are sharpened by a steel. The workman seizes the tool in his two hands, so as to place the edge perpendicularly to the skin, and pressing it carefully from above downwards, removes the fleshy excrescences, and lays them aside for making glue. He now turns round the *herse* upon the wall, in order to get access to the outside of the skin, and to scrape it with the tool inverted, so as to run no risk of cutting the epidermis. He thus removes any adhering filth, and squeezes out some water. The skin must next be ground. For this purpose it is sprinkled upon the fleshy side with sifted chalk or slaked lime, and then rubbed in all directions with a piece of pumice-stone, 4 or 5 inches in area, previously flattened upon a sandstone. The lime gets soon moist from the water contained in the skin. The pumice-stone is then rubbed over the other side of the skin, but without chalk or lime. This operation is necessary only for the best parchment or vellum. The skin is now allowed to dry upon the frame; being carefully protected from sunshine, and from frost. In the arid weather of summer a moist cloth needs to be applied to it from time to time, to prevent its drying too suddenly; immediately after which the skewers require to be tightened.

When it is perfectly dry, the white color is to be removed by rubbing it with the woolly side of a lambskin. But great care must be taken not to fray the surface; a circumstance of which some manufacturers are so much afraid, as not to use either chalk or lime in the polishing. Should any grease be detected upon it, it must be removed by steeping it in a lime pit for 10 days, then stretching it anew upon the *herse*, after which it is transferred to the *scraper*

This workman employs here an edge tool of the same shape as the fleshing-knife, but larger and sharper. He mounts the skin upon a frame like the *herse* above described; but he extends it merely with cords, without skewers or pins, and supports it generally upon a piece of raw calfskin, strongly stretched. The tail of the skin being placed towards the bottom of the frame, the workman first pares off, with a sharp knife, any considerable roughnesses, and then scrapes the outside surface obliquely downwards with the proper tools, till it becomes perfectly smooth: the fleshy side needs no such operation, and indeed were both sides scraped, the skin would be apt to become too thin, the only object of the scraper being to equalize its thickness. Whatever irregularities remain, may be removed with a piece of the finest pumice-stone, well flattened beforehand upon a fine sandstone. This process is performed by laying the rough parchment upon an oblong plank of wood, in the form of a stool; the plank being covered with a piece of soft parchment stuffed with wool, to form an elastic cushion for the grinding operation. It is merely the outside surface that requires to be pumiced. The celebrated Strasburgh vellum is prepared with remarkably fine pumice-stones.

If any small holes happen to be made in the parchment, they must be neatly patched, by cutting their edges thin, and pasting on small pieces with gum water.

The skins for drum-heads, sieves, and battledoors are prepared in the same way. For drums, the skins of asses, calves, or wolves are employed; the last being preferred. Ass skins are used for battledoors. For sieves, the skins of calves, she-goats, and, best of all, he-goats are employed. Church books are covered with the dressed skins of pigs.

Parchment is colored only green. The following is the process. In 500 parts of rain water, boil 8 of cream of tartar, and 30 of crystallized verdigris; when this solution is cold, pour into it 4 parts of nitric acid. Moisten the parchment with a brush, and then apply the above liquid evenly over its surface. Lastly, the necessary lustre may be given with white of eggs, or mucilage of gum arabic.

PARTING (*Départ*, Fr.; *Scheidung*, Germ.), is the process by which gold is separated from silver. See ASSAY, GOLD, REFINING, and SILVER.

PASTEL, is the French name of colored crayons.

PASTEL, is a dye stuff, allied to INDIGO, which see.

PASTES, or FACTITIOUS GEMS. (*Pierres précieuses artificielles*, Fr.; *Glaspasten*, Germ.) The general vitreous body called Strass, (from the name of its German inventor,) preferred by Fontanier in his treatise on this subject, and which he styles the Mayence base, is prepared in the following manner:—8 ounces of pure rock-crystal or flint in powder, mixed with 24 ounces of salt of tartar, are to be baked and left to cool. The mixture is to be afterwards poured into a basin of hot water, and treated with dilute nitric acid till it ceases to effervesce; and then the frit is to be washed till the water comes off tasteless. This is to be dried, and mixed with 12 ounces of fine white-lead, and the mixture is to be levigated and elutriated with a little distilled water. An ounce of calcined borax being added to about 12 ounces of the preceding mixture in a dry state, the whole is to be rubbed together in a porcelain mortar, melted in a clean crucible, and poured out into cold water. This vitreous matter must be dried, and melted a second and a third time, always in a new crucible, and after each melting poured into cold water, as at first, taking care to separate the lead that may be revived. To the third frit, ground to powder, 5 drachms of nitre are to be added; and the mixture being melted for the last time, a mass of crystal will be found in the crucible, of a beautiful lustre. The diamond may be well imitated by this Mayence base. Another very fine white crystal may be obtained, according to M. Fontanier, from 8 ounces of white-lead, 2 ounces of powdered borax, ½ grain of manganese, and 3 ounces of rock-crystal, treated as above.

The colors of artificial gems are obtained from metallic oxydes. The *oriental topaz* is prepared by adding oxyde of antimony to the base; the amethyst, by manganese with a little of the purple of Cassius; the beryl, by antimony and a very little cobalt; yellow artificial diamond and opal, by horn-silver (chloride of silver); blue-stone or sapphire, by cobalt. The following proportions have been given:—

For the *yellow diamond*. To 1 ounce of strass add 24 grains of chloride of silver, or 10 grains of glass of antimony.

For the *sapphire*. To 24 ounces of strass, add 2 drachms and 26 grains of the oxyde of cobalt.

For the *oriental ruby*. To 16 ounces of strass, add a mixture of 2 drachms and 48 grains of the precipitate of Cassius, the same quantity of peroxyde of iron prepared by nitric acid, the same quantity of golden sulphuret of antimony and of manganese calcined with nitre, and 2 ounces of rock crystal. Manganese alone, combined with the base in proper quantity, is said to give a ruby color.

For the *emerald*. To 15 ounces of strass, add 1 drachm of mountain blue (carbonate of copper), and 6 grains of glass of antimony; or, to 1 ounce of base, add 20 grains of glass of antimony, and 3 grains of oxyde of cobalt.

For the *common opal*. To 1 ounce of strass, add 10 grains of horn-silver, 2 grains of calcined magnetic ore, and 26 grains of an absorbent earth (probably chalk-marl) *Fontanier*.

M. Douault-Wiéland, in an experimental memoir on the preparation of artificial colored stones, has offered the following instructions, as being more exact than what were published before.

The base of all artificial stones is a colorless glass, which he calls *fondant*, or flux; and he unites it to metallic oxydes, in order to produce the imitations. If it be worked alone on the lapidary's wheel, it counterfeits brilliants and rose diamonds remarkably well.

This base or strass is composed of silex, potash, borax, oxyde of lead, and sometimes arsenic. The silicious matter should be perfectly pure; and if obtained from sand, it ought to be calcined and washed, first with dilute muriatic acid, and then with water. The crystal or flint should be made redhot, quenched in water, and ground, as in the potteries. The potash should be purified from the best pearlash; and the borax should be refined by one or two crystallizations. The oxyde of lead should be absolutely free from tin, for the least portion of this latter metal causes milkiness. Good red-lead is preferable to litharge. The arsenic should also be pure. Hessian crucibles are preferable to those of porcelain, for they are not so apt to crack and run out. Either a pottery or porcelain kiln will answer, and the fusion should be continued 24 hours; for the more tranquil and continuous it is, the denser is the paste, and the greater its beauty. The following four recipes have afforded good strass:—

No. I.

	Grains.
Rock crystal - - - - -	4056
Minium - - - - - -	6300
Pure potash - - - - -	2154
Borax - - - - - -	276
Arsenic - - - - - -	12

No. II.

Sand - - - - - - -	3600
Ceruse of Clichy (pure carbonate of lead) - - - - - -	8508
Potash - - - - - -	1260
Borax - - - - - -	360
Arsenic - - - - - -	12

No. III.

	Grains.
Rock crystal - - - - -	3456
Minium - - - - - -	5328
Potash - - - - - -	1944
Borax - - - - - -	216
Arsenic - - - - - -	6

No. IV.

Rock crystal - - - - -	3600
Ceruse of Clichy - -	8508
Potash - - - - - -	1260
Borax - - - - - -	360

Topaz.

	Grains.
Very white paste - - - - - - - - - -	1008
Glass of antimony - - - - - - - - - -	43
Cassius purple - - - - - - - - - -	1
Or,	
Paste - - - - - - - - - - - - -	3456
Oxyde of iron, called Saffron of Mars - - - - -	36

Ruby.

M. Wiéland succeeded in obtaining excellent imitations of rubies, by making use of the topaz materials. It often happened that the mixture for topazes gave only an opaque mass, translucent at the edges, and in thin plates of a red color. 1 part of this substance being mixed with 8 parts of strass, and fused for 30 hours, gave a fine yellowish crystal-like paste, and fragments of this fused before the blowpipe, afforded the finest imitation of rubies. The result was always the same.

The following are other proportions for rubies:—

	Grains.
Paste - - - - - - - - - - - - -	2880
Oxyde of manganese - - - - - - - - -	72

Emerald.

Paste - - - - - - - - - -	4608
Green oxyde of pure copper - - - - - - -	42
Oxyde of chrome - - - - - - - - - -	2

Sapphire.	Grains.
Paste	4608
Oxyde of cobalt	68

This mixture should be carefully fused in a luted Hessian crucible, and be left 30 hours in the fire.

Amethyst.	Grains.
Paste	4608
Oxyde of manganese	36
Oxyde of cobalt	24
Purple of Cassius	1

Syrian Garnet, or Ancient Carbuncle.	Grains.
Paste	512
Glass of antimony	256
Cassius purple	2
Oxyde of manganese	2

Beryl, or Aqua Marina.	Grains.
Paste	3456
Glass of antimony	24
Oxyde of cobalt	1½

In all these mixtures, the substances should be mixed by sifting, fused very carefully, and cooled very slowly, after having been left in the fire from 24 to 30 hours.

M. Lançon has also made many experiments on the same subject. The following are a few of his proportions:—

Paste.	Grains.
Litharge	100
White sand	75
White tartar, or potash	10

Amethyst.	Grains.
Paste	9216
Oxyde of manganese	from 15 to 24
Oxyde of cobalt	1

Emerald.	Grains.
Paste	9216
Acetate of copper	72
Peroxyde of iron, or saffron of Mars	1·5

PASTILLE is the English name of small cones made of gum benzoin, with powder of cinnamon, and other aromatics, which are burned as incense, to diffuse a grateful odor, and conceal unpleasant smells in apartments. See PERFUMERY.

PASTILLE is the French name of certain aromatic sugared confections; called also *tablettes.*

PEARLASH, a commercial form of POTASH, which see.

PEARLS (*Perles* Fr.; *Perlen*, Germ.), are the productions of certain shell-fish. These molluscæ are subject to a kind of disease caused by the introduction of foreign bodies within their shells. In this case, their pearly secretion, instead of being spread in layers upon the inside of their habitation, is accumulated round these particles in concentric layers. Pearl consists of carbonate of lime, interstratified with animal membrane.

The oysters whose shells are richest in mother of pearl, are most productive of these highly prized spherical concretions. The most valuable pearl fisheries are on the coast of Ceylon, and at Olmutz in the Persian Gulf, and their finest specimens are more highly prized in the East than diamonds, but in Europe they are liable to be rated very differently, according to the caprice of fashion. When the pearls are large, truly spherical, reflecting and decomposing the light with much vivacity, they are much admired. But one of the causes which renders their value fluctuating, is the occasional loss of their peculiar lustre, without our being able to assign a satisfactory reason for it. Besides, they can be now so well imitated, that the artificial pearls have nearly as rich an appearance as the real.

PEARLS, ARTIFICIAL. These are small globules or pear-shaped spheroids of thin glass, perforated with two opposite holes, through which they are strung, and mounted into necklaces, &c., like real pearl ornaments. They must not only be white and brilliant, but exhibit the iridescent reflections of mother of pearl. The liquor employed to imitate the pearly lustre, is called the *essence of the East* (*essence d' orient*), which is prepared by throwing into water of ammonia the brilliant scales, or rather the *lamellæ*, separated by washing and friction, of the scales of a small river fish, the blay, called in French *ablette*. These scales digested in ammonia, having acquired a degree of softness and flexibility which allow of their application to the inner surfaces of the glass globules, they are introduced by suction of the liquor containing them in suspension. The ammonia is volatilized in the act of drying the globules.

It is said that some manufacturers employ ammonia merely to prevent the alteration of the scales; that when they wish to make use of them, they suspend them in a well clarified solution of isinglass, then pour a drop of the mixture into each bead, and spread it round the inner surface. It is doubtful whether, by this method, the same lustre and play of colors can be obtained as by the former. It seems moreover to be of importance for the success of the imitation, that the globules be formed of a bluish, opalescent, very thin glass, containing but little potash and oxyde of lead. In every manufactory of artificial pearls, there must be some workmen possessed of great experience and dexterity. The French are supposed to excel in this ingenious branch of industry.

PEARL WHITE is a submuriate of bismuth, obtained by pouring a solution of the nitrate of that metal into a dilute solution of sea-salt, whereby a light and very white powder is obtained, which is to be well washed and dried. See Bismuth.

PECTIC ACID (*Acide pectique*, Fr.; *Gallertsaüre*, Germ.), so named on account of its jellying property, from πηκτις, *coagulum*, exists in a vast number of vegetables. The easiest way of preparing it, is to grate the roots of carrots into a pulp, to express their juice, to wash the *marc* with rain or distilled water, and to squeeze it well; 50 parts of the marc are next to be diffused through 300 of rain-water, adding by slow degrees a solution of one part of pure potash, or two of bicarbonate. This mixture is to be heated, so as to be made to boil for about a quarter of an hour, and is then to be thrown boiling-hot upon a filter cloth. It is known to have been well enough boiled, when a sample of the filtered liquor becomes gelatinous by neutralizing it with an acid. This liquor contains pectate of potassa, in addition to other matters extricated from the root. The pectate may be decomposed by a stronger acid, but it is better to decompose it by muriate of lime; whereby a pectate of lime, in a gelatinous form, quite insoluble in water, is obtained. This having been washed with cold water upon a cloth, is to be boiled in water containing as much muriatic acid as will saturate the lime. The pectic acid thus liberated, remains under the form of a colorless jelly, which reddens litmus paper, and tastes sour, even after it is entirely deprived of the muriatic acid. Cold water dissolves very little of it; it is more soluble in boiling water. The solution is colorless, does not coagulate on cooling, and hardly reddens litmus paper; but it gelatinizes when alcohol, acids, alkalis, or salts are added to it. Even sugar transforms it, after some time, into a gelatinous state, a circumstance which serves to explain the preparation of apple, cherry, raspberry, gooseberry, and other jellies.

PECTINE, or vegetable jelly, is obtained by mixing alcohol with the juice of ripe currants, or any similar fruit, till a gelatinous precipitate takes place; which is to be gently squeezed in a cloth, washed with a little weak alcohol, and dried. Thus prepared, pectine is insipid, without action upon litmus, in small pieces, semi-transparent, and of a membranous aspect, like isinglass. Its mucilaginous solution in cold water is not tinged blue with iodine. A very small addition of potash, or its carbonate, converts pectine into pectic acid; both of which substances are transformed into mucic and oxalic acids by the nitric.

PELTRY (*Pelleterie*, Fr.; *Pelzwerk*, Germ.), is nearly synonymous with fur, and comprehends the skins of different kinds of wild animals that are found in high northern latitudes, particularly in the American continent; such as the beaver, bear, moosedeer, marten, mink, sable, wolverine, wolf, &c. When these skins have received no preparation but from the hunters, they are most properly called peltry; but when they have had the inner side tawed or tanned (see Leather) by an aluminous process, they may then be denominated *furs*.

The scouring or cleaning of peltry is performed in a large cask, or truncated cone laid on its side, and traversed by a revolving shaft, which is furnished with a few rectangular rounded pegs. These are intended to stir round the skins, while they are dusted over with Paris plaster, whitening, or sometimes sand, made as hot as the hand can bear. The bottom of the cask should be grated, to allow the impurities to fall out. The *lustrage*, which the cleansed skins next undergo, is merely a species of dyeing, either topical, to modify certain disagreeable shades, or general, to impart a more beautiful color to the fur. Under the articles Dyeing, and the several colors, as also Hair and Morocco, sufficient instructions will be found for dyeing fur. The mordants should be applied pretty hot by a brush, on the hair of the skin, stretched upon a solid table; and after two or three applications, with drying between, the tinctorial infusions may be rubbed on in the same way. The hair must be freed beforehand from all greasiness, by lime water, or a weak solution of carbonate of soda; then well washed. Much nicety, and many successive applications of the dye-stuff, are sometimes requisite to bring out the desired shade.

Under Hat Manufacture, I referred to this article for a description of the process of *sécretage*, whereby the hairs of rabbit and hare skins are rendered fit for felting. Dissolve 32 parts of quicksilver in 500 of common aquafortis; and dilute the solution with one half or two thirds of its bulk of water, according to the strength of the acid. The skin being laid upon a table with the hair side uppermost, a brush, made with the bristles of the wild boar, is to be slightly moistened with the mercurial solution, and passed over the smooth surface of the hairs with strong pressure. This application must be repeated several times in succession, till every part of the fur be equally touched, and till about two thirds of the length of the hairs be moistened, or a little more, should they be rigid. In order to complete this impregnation, the skins are laid together in pairs with the hairy sides in contact, put in this state into the stove-room, and exposed to a heat higher in proportion to the weakness of the mercurial solution. The drying should be rapidly effected, otherwise the concentration of the nitrate will not take due effect in causing the retraction and curling of the hairs.

No other acid, or metallic solution, but the above, has been found to answer the desired purpose of the hatmaker. After the hairs are properly *secreted*, they are plucked off by hand, or shorn off by a machine.

PENCIL MANUFACTURE. (*Crayons, fabrique de*, Fr.; *Bleistifte, verfertigung*, Germ.) The word pencil is used in two senses. It signifies either a small hair brush employed by painters in oil and water colors, or a slender cylinder, of black lead or plumbago, either naked or enclosed in a wooden case, for drawing black lines upon paper. The last sort, which is the one to be considered here, corresponds nearly to the French term crayon, though this includes also pencils made of differently colored earthy compositions. See CRAYON.

The best black-lead pencils of this country are formed of slender parallelopipeds, cut out by a saw from sound pieces of plumbago, which have been previously calcined in close vessels at a bright red heat. These parallelopipeds are generally enclosed in cases made of cedar wood, though of late years they are also used alone, in peculiar pencil-cases, under the name of ever-pointed pencils, provided with an iron wire and screw, to protrude a minute portion of the plumbago beyond the tubular metallic case, in proportion as it is wanted.

In the year 1795, M. Conté, a French gentleman, well acquainted with the mechanical arts, invented an ingenious process for making artificial black-lead pencils of superior quality, by which he and his successor and son-in-law, M. Humblot, have realized large fortunes.

Pure clay, or clay containing the smallest proportion of calcareous or silicious matter, is the substance which he employed to give aggregation and solidity, not only to plumbago dust, but to all sorts of colored powders. That earth has the property of diminishing in bulk, and increasing in hardness, in exact proportion to the degree of heat it is exposed to, and hence may be made to give every degree of solidity to crayons. The clay is prepared by diffusing it in large tubs through clear river water, and letting the thin mixture settle for two minutes. The supernatant milky liquor is drawn off by a syphon from near the surface, so that only the finest particles of clay are transferred into the second tub, upon a lower level. The sediment, which falls very slowly in this tub, is extremely soft and plastic. The clear water being run off, the deposite is placed upon a linen filter, and allowed to dry. It is now ready for use.

The plumbago must be reduced to a fine powder in an iron mortar, then put into a crucible, and calcined at a heat approaching to whiteness. The action of the fire gives it a brilliancy and softness which it would not otherwise possess, and prevents it from being affected by the clay, which it is apt to be in its natural state. The less clay is mixed with the plumbago, and the less the mixture is calcined, the softer are the pencils made of it; the more clay is used the harder are the pencils. Some of the best pencils made by M. Conté, were formed of two parts of plumbago and three parts of clay; others of equal parts. This composition admits of indefinite variations, both as to the shade and hardness; advantages not possessed by the native mineral. While the traces may be made as black as those of pure plumbago, they have not that glistening aspect which often impairs the beauty of black-lead drawings. The same lustre may, however, be obtained by increasing the proportion of powdered plumbago relatively to the clay.

The materials having been carefully sifted, a little of the clay is to be mixed with the plumbago, and the mixture is to be triturated with water into a perfectly uniform paste. A portion of this paste may be tested by calcination. If on cutting the indurated mass, particles of plumbago appear, the whole must be further levigated. The remainder of the clay is now to be introduced, and the paste is to be ground with a muller upon a porphyry slab, till it be quite homogeneous, and of the consistence of thin dough. It is now to be made into a ball, put upon a support, and placed under a bell glass inverted in a basin of water, so as to be exposed merely to the moist air.

Small grooves are to be made in a smooth board, similar to the pencil parallelopipeds, but a little longer and wider, to allow for the contraction of volume. The wood must be boiled in grease, to prevent the paste from sticking to it. The above described paste being pressed with a spatula into these grooves, another board, also boiled in grease, is to be laid over them very closely, and secured by means of screw-clamps. As the atmospheric air can get access only to the ends of the grooves, the ends of the pencil-pieces become dry first, and by their contraction in volume get loose in the grooves, allowing the air to insinuate further, and to dry the remainder of the paste in succession. When the whole piece is dried, it becomes loose, and might be turned out of the grooves. But before this is done, the mould must be put into an oven moderately heated, in order to render the pencil pieces still drier. The mould should now be taken out, and emptied upon a table covered with cloth. The greater part of the pieces will be entire, and only a few will have been broken, if the above precautions have been duly observed. They are all, however, perfectly straight, which is a matter of the first importance.

In order to give solidity to these pencils, they must be set upright in a crucible till it is filled with them, and then surrounded with charcoal powder, fine sand, or sifted wood ashes. The crucible, after having a luted cover applied, is to be put into a furnace, and exposed to a degree of heat regulated by the pyrometer of Wedgewood; which degree is proportional to the intended hardness of the pencils. When they have been thus baked, the crucible is to be removed from the fire, and allowed to cool with the pencils in it.

Should the pencils be intended for drawing architectural plans, or for very fine lines, they must be immersed in melted wax or suet nearly boiling hot, before they are put into the cedar cases. This immersion is best done by heating the pencils first upon a grid-iron, and then plunging them into the melted wax or tallow. They acquire by this means a certain degree of softness, are less apt to be abraded by use, and preserve their points much better.

When these pencils are intended to draw ornamental subjects with much shading, they should not be dipped as above.

Second process for making artificial pencils, somewhat different from the preceding.—All the operations are the same, except that some lamp-black is introduced along with the plumbago powder and the clay. In calcining these pencils in the crucible, the contact of air must be carefully excluded, to prevent the lamp-black from being burned away on the surface. An indefinite variety of pencils, of every possible black tint, may thus be produced, admirably adapted to draw from nature.

Another ingenious form of mould is the following:

Models of the pencil-pieces must be made in iron, and stuck upright upon an iron tray, having edges raised as high as the intended length of the pencils. A metallic alloy is made of tin, lead, bismuth, and antimony, which melts at a moderate heat. This is poured into the sheet-iron tray, and after it is cooled and concreted, it is inverted, and shaken off from the model bars, so as to form a mass of metal perforated throughout with tubular cavities, corresponding to the intended pencil-pieces. The paste is introduced by pressure into these cavities, and set aside to dry slowly. When nearly dry, the pieces get so much shrunk that they may be readily turned out of the moulds upon a cloth table. They are then to be completely desiccated in the shade, afterwards in a stove-room, next in the oven, and lastly ignited in the crucible, with the precautions above prescribed.

M. Conté recommends the hardest pencils of the architect to be made of lead melted with some antimony and a little quicksilver.

In their further researches upon this subject, M. Conté and M. Humblot found that the different degrees of hardness of crayons could not be obtained in a uniform manner by the mere mixture of plumbago and clay in determinate doses. But they discovered a remedy for this defect in the use of saline solutions, more or less concentrated, into which they plunged the pencils, in order to modify their hardness, and increase the uniformity of their texture. The non-deliquescent sulphates were preferred for this purpose; such as sulphate of soda, &c. Even sirup was found useful in this way.

PENS, STEEL. The best metal, made from Dannemora or hoop (L) iron, is selected, and laminated into slips about 3 feet long, and 4 inches broad, of a thickness corresponding to the desired stiffness and flexibility of the pens. These slips are subjected to the action of a stamping-press, somewhat similar to that for making buttons. (See BUTTON, and PLATED WARE.) The point destined for the nib is next introduced into an appropriate gauged hole of a little machine, and pressed into the semi-cylindrical shape; where it is also pierced with the middle slit, and the lateral ones, provided the latter are to be given. The pens are now cleaned, by being tossed about among each other, in a tin cylinder, about 3 feet long, and 9 inches in diameter; which is suspended at each end upon joints, to two cranks, formed one on each of two shafts. The cylinder, by the rotation of a fly-wheel, acting upon the crank-shafts, is made to describe such revolutions as agitate the pens in all directions, and polish them by mutual attrition. In the course of 4 hours several thousand pens may be finished upon this machine.

PEPPER. (*Poivre*, Fr.; *Pfeffer*, Germ.) Black pepper is composed, according to M. Pelletier, of the vegetable principle, *piperine*, of a very acrid concrete oil, a volatile balsamic oil, a colored gummy matter, an extractive principle analogous to legumine, malic and tartaric acids, starch, bassorine, ligneous matter, with earthy and alkaline salts in small quantity. Cubebs pepper has nearly the same composition.

Pepper imported for home consumption, in	1835,	1836,	1837.—Duty 6d. per lb.
Lbs.	2,359,573;	2,800,980;	2,626,298.

PERFUMERY, ART OF (*Parfumerie*, Fr.; *Wohlriechende-kunst*, Germ.), consists in the preparation of different products, such as fats or pommades, essential oils, distilled spirits, pastes, pastilles, and essence.

Fats ought to be pounded in a marble mortar, without addition of water, till all the membranes be completely torn; then subjected to the heat of a water-bath in a proper vessel. The fat soon melts, and the albumen of the blood coagulating, carries with it all the foreign substances; the liquid matter should be skimmed, and passed through a canvass filter.

Of pommades by infusion.—Rose, orange-flower, and cassia. Take 334 pounds of hog's lard, and 166 of beef suet. These 500 pounds are put into a pan called *bugadier*; and when melted, 150 pounds of rose-leaves nicely plucked are added, taking care to stir the mixture every hour. The infusion thus prepared is to remain at rest for 24 hours; at the end of this time, the pommade is again melted, and well stirred to prevent its adherence to the bottom of the melting-pan. The mass is now to be poured out into canvass, and made into rectangular bricks or loaves, which are subjected to a press, in order to separate the solid matter from the soft pommade. These brick-shaped pieces being put into an iron-bound barrel perforated all over its staves, the pommade is to be allowed to exude on all sides, and flow down into a copper vessel placed under the trough of the press. This manipulation should be repeated with the same fat ten or twelve times; or in other words, 3000 pounds of fresh rose-leaves should be employed to make a good pommade.

The pommade of orange-flowers is made in the same manner, as also the pommade of cassia.

Of pommades without infusion.—Jasmine, tuberose, jonquil, narcissus, and violet.

A square frame, called *tiame*, is made of four pieces of wood, well joined together, 2 or 3 inches deep, into which a pane of glass is laid, resting upon inside ledges near the bottom. Upon the surface of the pane the simple pommade of hog's lard and suet is spread with a pallet knife; and into this pommade the sweet-scented flowers are stuck fresh in different points each successive day, during two or three months, till the pommade has acquired the desired richness of perfume. The above-described frames are piled closely over each other. Some establishments at *Grasse* possess from 3000 to 4000 of them.

Of oils.—Rose, orange-flower, and cassia oils, are made by infusion, like the pommades of the same perfumes; taking care to select oils perfectly fresh. As to those of jasmine, tuberose, jonquil, violet, and generally all delicate flowers, they are made in the following manner. Upon an iron frame, a piece of cotton cloth is stretched, imbued with olive oil of the first quality, and covered completely with a thin bed of flowers. Another frame is similarly treated, and in this way a pile is made. The flowers must be renewed till the oil is saturated with their odor. The pieces of cotton cloth are then carefully pressed to extrude the oil. This last operation requires commonly 7 or 8 days.

Of distillation.—The essential oils or essences, of which the great manufacture is in the south of France, are of rose, neroli, lavender, lemon thyme, common thyme, and rosemary. For the mode of distilling the essential oils, see OILS, ESSENTIAL.

The essence of roses being obtained in a peculiar manner, I shall describe it here. Put into the body of a still 40 pounds of roses, and 60 quarts of water; distil off one half of the water. When a considerable quantity of such water of the first distillation is obtained, it must be used as water upon fresh rose-leaves; a process of repetition to be carried to the fifth time. In the distillation of orange-flower, to obtain the essence of neroli, the same process is to be followed; but if orange-flower water merely be wanted, then it is obtained at one distillation, by reserving the first fifth part of water that comes over. What is called the essence of *petit-grain*, is obtained by distilling the leaves of the orange shrub. The essences of lavender, thyme, &c., present nothing peculiar in their mode of extraction.

OF SCENTED SPIRITS,

From oil of rose, orange, jasmine, tuberose, cassia, violet, and other flowers.

Into each of three digesters, immersed in water-baths, put 25 lbs. of any one of these oils, and pour into the first digester 25 quarts of spirit of wine; agitate every quarter of an hour during three days, and at the end of this period, draw off the perfumed spirit, and pour it into the second digester; then transfer it after 3 days into the third digester, treating the mixture in the same way; and the spirit thus obtained will be perfect. The digesters must be carefully covered during the progress of these operations. On pursuing the same process with the same oil and fresh alcohol, essences of inferior qualities may be obtained, called Nos. 2, 3, and 4.

Some perfumers state that it is better to use highly scented pommades than oils; but there is probably little difference in this respect.

Esprit de Suave.

7 Eng. qrts. of spirit of jasmine,3d operation.
7 — cassia, —
3 — wine.
2 — tuberose, —
1½ ounce essence of cloves.
¼ ounce fine neroli.
1½ ounce essence of bergamot.
8 ounces essence of musk, 2d infusion.
3 quarts rose water.

Spirit of Cythera.

1 quart spirit of violets.
1 — jasmine, 2d operation.
1 — tuberose, —
1 — clove gillyflower.
1 — roses, 2d operation.
1 — Portugal.
2 — orange-flower water.

Spirit of flowers of Italy.

2 quarts spirit of jasmine, 2d operation.
2 — roses, —
2 — oranges, 3d —
2 quarts spirit of cassia, 2d operation.
1½ — orange flower water.

The above spirits mark usually 28 alcometric degrees of Gay Lussac. See ALCOHOL.

POMMADES.

No less than 20 scented pommades are distinguished by the perfumers of Paris. The essences commonly employed in the manufacture of pommades, are those of bergamot, lemons, *cédrat*, *limette* (sweet lemon), Portugal, rosemary, thyme, lemon thyme, lavender, marjoram, and cinnamon.

The following may serve as an example:—

Pommade à la vanille, commonly called Roman.

12 pounds of pommade à la rose.
3 — oil à la rose.
1 — vanilla, first quality, pulverized.
6 ounces bergamot.

The pommade being melted at the heat of a water-bath, the vanilla is to be introduced with continual stirring for an hour. The mixture is left to settle during two hours. The pommade is then to be drawn off, and will be found to have a fine yellow color, instead of the brown shade which it commonly has.

In making odoriferous extracts and waters, the spirits of the flowers prepared by macerating the flowers in alcohol should be preferred to their distillation, as forming the foundation of good perfumery. The specific gravity of these spirits should be always under 0·88.

Extract of Nosegay (bouquet).

2 quarts spirit of jasmine, 1st operation.
2 — extract of violets.
1 — spirit of cassia, 1st —
1 — roses, - 1st —
1 — orange, - 1st —
1 — Extract of clove gillyflower.
4 drms. of flowers of benzoin (benzoic acid).
8 ounces of essence of amber, 1st infusion.

Extract of peach blossoms.

6 quarts of spirits of wine.
6 pounds of bitter almonds.
2 quarts of spirits of orange flower, 2d operation.
4 drachms of essence of bitter almonds.
4 drachms of balsam of Peru.
4 ounces of essence of lemons.

Eau de Cologne.

Two processes have been adopted for the preparation of this perfume, distillation and infusion; the first of which, though generally abandoned, is, however, the preferable one. The only essences which should be employed, and which have given such celebrity to this water, are the following; bergamot, lemon, rosemary, Portugal, neroli. The whole of them ought to be of the best quality, but their proportions may be varied according to the taste of the consumers.

Thirty different odors are enumerated by perfumers; the three following recipes will form a sufficient specimen of their combinations.

Honey-water.

6 quarts of spirit of roses, 3d operation.
3 do. jasmine.
3 do. spirits of wine.
3 ounces essence of Portugal.
4 drachms flowers of benzoin.
12 ounces of essence of vanilla, 3d infusion.
12 do. musk, do.
3 quarts good orange-flower water.

Eau de mille fleurs.

18 quarts of spirits of wine.
4 ounces balsam of Peru.
8 do. essence of bergamot.
4 do. cloves.
1 do. ordinary neroli.
1 do. thyme.
8 do. musk, 3d infusion.
4 quarts orange flower water.

Eau de mousseline.

rts spirit of roses, 3d infusion.
. jasmine, 4th do.
. clove gillyflower.
. orange flower, 4th do

2 ounces essence of vanilla, 3d infusion.
2 do. musk, do.
4 drachms of sanders wood.
1 quart of orange-flower water.

Almond pastes.

ese are, gray, sweet white, and bitter white.

e first is made either with the kernels of apricots, or with bitter almonds. They innowed, ground, and formed into loaves of 5 or 6 pounds weight, which are put he press in order to extract their oil; 300 pounds of almonds affording about 130 of The pressure is increased upon them every two hours during three days; at the end ich time the loaves or cakes are taken out of the press to be dried, ground, and

s second paste is obtained by boiling the almonds in water till their skins are com- y loosened; they are next put into a basket, washed and blanched; then dried, and d as above.

third paste is prepared like the second, only using bitter almonds.

id almond pastes, such as those of the rose, orange, vanilla, and nosegay. The paste is most admired. It is prepared as follows;—

6 pounds of honey.
6 do. white bitter paste.

12 pounds oil of bitter almonds.
26 yolks of eggs.

honey should be heated apart and strained; 6 pounds of almond paste must then eaded with it, adding towards the conclusion, alternately, the quantity of yolks of nd almond oil indicated.

Pastilles à la rose, orange flower, and vanilla.

Pastilles à la rose.

12 ounces of gum.
12 do. olibanum, in tears.
12 do. storax, do.
8 do. nitre.
16 do. powder of pale roses.
ds 14 do. charcoal powder.
1 do. essence of roses.

Pastilles of orange flower.

12 ounces of gum galbanum.
12 do. olibanum, in tears.
12 do. storax, do.
8 do. nitre.
1 pound of pure orange powder.
3 do. 14 ounces charcoal powder.
1 ounce superfine neroli.

Pastilles à la vanille.

12 ounces of gum galbanum.
12 do. olibanum, in tears.
12 do. storax do.
8 do. nitre.
8 do. cloves.

16 ounces powder of vanilla.
3 pounds 14 ounces charcoal powder.
4 drms. essence of cloves.
8 ounces do. vanilla, 1st infusion.

above mixture in each case is to be thickened with 2 ounces of gum tragacanth ed in 2 pints of rose water. It is needless to say that the ingredients of the mix- ould be impalpable powders.

Scented cassolettes.

unds of black amber (ambergris).
lo. rose powder.
nces of benzoin.

1 ounce essence of roses.
1 do. gum tragacanth.
A few drops of the oil of sanders wood.

se ingredients are pulverized, and made into a cohesive paste with the gum.

ESSENCES BY INFUSION.

Essence of musk.

5 ounces of musk from the bladder, cut small.
1 do. civet.
4 quarts of spirit of ambrette (purple sweet sultan).

whole are put into a matrass, and exposed to the sun for two months during ttest season of the year. In winter, the heat of a water bath must be re- to.

Essence of vanilla.

3 pounds of vanilla in branches, 1st quality, cut small.
4 quarts spirit of ambrette.
2 drachms of cloves.
½ do. musk from the bladder.

same process must be followed as for the essence of musk.

Essence of Ambergris.

4 ounces of ambergris.
2 ounces of bladder musk.
8 quarts of spirit of ambrette.
Treat as above.

Spirit of ambrette (purple sweet sultan).

25 pounds of ambrette are to be distilled with 25 quarts of spirits of wine, adding 12 quarts of water, so as to be able to draw off the 25 quarts.

PERRY is the fermented juice of pears, prepared in exactly the same way as CIDER.

PERSIAN BERRIES. See BERRIES, PERSIAN.

PETROLEUM. See NAPTHA.

PE-TUNT-SE is the Chinese name of the fusible earthy matter of their porcelain. It is analogous to our Cornish stone.

PEWTER, PEWTERER. (*Potier d'étain*, Fr.) Pewter is, generally speaking, an alloy of tin and lead, sometimes with a little antimony or copper, combined in several different proportions, according to the purposes which the metal is to serve. The English tradesmen distinguish three sorts, which they call plate, trifle, and ley pewter; the first and hardest being used for plates and dishes; the second for beer-pots; and the third for larger wine measures. The plate pewter has a bright silvery lustre when polished; the best is composed of 100 parts of tin, 8 parts of antimony, 2 parts of bismuth, and 2 of copper. The trifle is said by some to consist of 83 of tin, and 17 of antimony; but it generally contains a good deal of lead. The ley pewter is composed of 4 of tin, and 1 of lead. As the tendency of the covetous pewterer is always to put in as much of the cheap metal as is compatible with the appearance of his metal in the market, and as an excess of lead may cause it to act poisonously upon all vinegars and many wines, the French government long ago appointed Fourcroy, Vauquelin, and other chemists, to ascertain by experiment the proper proportions of a safe pewter alloy. These commissioners found that 18 parts of lead might, without danger of affecting wines, &c., be alloyed with 82 parts of tin; and the French government in consequence passed a law requiring pewterers to use 83½ of tin in 100 parts, with a tolerance of error amounting to 1½ per cent. This ordonnance, allowing not more than 18 per cent. of lead at a maximum, has been extended to all vessels destined to contain alimentary substances. A table of specific gravities was also published, on purpose to test the quality of the alloy; the density of which, at the legal standard, is 7·764. Any excess of lead is immediately indicated by an increase in the specific gravity above that number.

The pewterer fashions almost all his articles by casting them in moulds of brass or bronze, which are made both inside and outside in various pieces, nicely fitted together, and locked in their positions by ears and catches or pins of various kinds. The moulds must be moderately heated before the pewter is poured into them, and their surfaces should be brushed evenly over with pounce powder (sandarach) beaten up with white of egg. Sometimes a film of oil is preferred. The pieces, after being cast, are turned and polished; and if any part needs soldering, it must be done with a fusible alloy of tin, bismuth, and lead.

Britannia metal, the kind of pewter of which English tea-pots are made, is said to be an alloy of equal parts of brass, tin, antimony, and bismuth; but the proportions differ in different workshops, and much more tin is commonly introduced. Queen's metal is said to consist of 9 parts of tin, 1 of antimony, 1 of bismuth, and 1 of lead; it serves also for teapots and other domestic utensils.

A much safer and better alloy for these purposes may be compounded by adding to 100 parts of the French pewter, 5 parts of antimony, and 5 of brass to harden it. The English ley pewter contains often much more than 20 per cent. of lead. Under TIN, will be found the description of an easy method of analyzing its lead alloys.

PHOSPHORIC ACID is the acid formed by the vivid combustion of

PHOSPHORUS. This interesting simple combustible, being an object of extensive consumption, and therefore of a considerable chemical manufacture, I shall describe the requisite manipulations for preparing it at some detail. Put 1 cwt. of finely ground bone-ash, such as is used by the assayers, into a stout tub, and let one person work it into a thin pap with twice its weight of water, and let him continue to stir it constantly with a wooden bar, while another person pours into it, in a uniform but very slender stream, 78 pounds of concentrated sulphuric acid.

The heat thus excited in the dilution of the acid, and in its reaction upon the calcareous base, is favorable to the decomposition of the bone phosphate. Should the resulting sulphate of lime become lumpy, it must be reduced into a uniform paste, by the addition of a little water from time to time. This mixture must be made out of doors, as under an open shed, on account of the carbonic acid and other offensive gases which are extricated. At the end of 24 hours, the pap may be thinned with water, and, if convenient, heated, with careful stirring, to complete the chemical change, in a square pan made of sheet lead, simply folded up at the sides. Whenever the paste has lost its granular character, it is ready for transfer into a series of tall casks, to be further diluted and settled, whereby the clear superphosphate of lime may be run off by a syphon from the deposite of gypsum. More water must then be mixed with the precipitate, after subsidence of which, the supernatant liquor is again to be drawn off. The skilful operator employs the weak acid from one cask to wash the deposite in another, and thereby saves fuel in evaporation.

The collected liquors being put into a leaden, or preferably a copper pan, of proper dimensions, are to be concentrated by steady ebullition, till the calcareous deposite becomes considerable; after the whole has been allowed to cool, the clear liquor is to be run off, the sediment removed, and thrown on a filter. The evaporation of the clear liquor is to be urged till it acquires the consistence of honey. Being now weighed, it should amount to 37 pounds. One fourth of its weight of charcoal in fine powder, that is, about 9 pounds, are then to be incorporated with it, and the mixture is to be evaporated to dryness in a cast-iron pot. A good deal of sulphurous acid is disengaged along with the steam at first, from the reaction of the sulphuric acid upon the charcoal, and afterwards some sulphureted hydrogen. When the mixture has become perfectly dry, as shown by the redness of the bottom of the pot, it is to be allowed to cool, and packed tight into stoneware jars fitted with close covers, till it is to be subjected to distillation. For this purpose, earthen retorts of the best quality, and free from air-holes, must be taken, and evenly luted over their surface with a compost of fire-clay and horse-dung. When the coating is dry and sound, the retort is to be two thirds filled with the powder, and placed upon proper supports in the laboratory of an air-furnace, having its fire placed not immediately beneath the retort, but to one side, after the plan of a reverberatory; whereby the flame may play uniformly round the retort, and the fuel may be supplied as it is wanted, without admitting cold air to endanger its cracking. The gallery furnace of the palatinate (under MERCURY) will show how several retorts may be operated upon together, with one fire.

To the beak of the retort properly inclined, the one end of a bent copper tube is to be tightly luted, while the other end is plunged not more than one quarter of an inch beneath the surface of water contained in a small copper or tin trough placed beneath, close to the side of the furnace, or in a wide-mouthed bottle. It is of advantage to let the water be somewhat warm, in order to prevent the concretion of the phosphorus in the copper tube, and the consequent obstruction of the passage. Should the beak of the retort appear to get filled with solid phosphorus, a bent rod of iron may be heated, and passed up the copper tube, without removing its end from the water. The heat of the furnace should be most slowly raised at first, but afterwards equably maintained in a state of bright ignition. After 3 or 4 hours of steady firing, carbonic acid and sulphurous acid gases are evolved in considerable abundance, provided the materials had not been well dried in the iron pot; then sulphureted hydrogen makes its appearance, and next phosphureted hydrogen, which last should continue during the whole of the distillation.

The firing should be regulated by the escape of this remarkable gas, which ought to be at the rate of about 2 bubbles per second. If the discharge comes to be interrupted, it is to be ascribed either to the temperature being too low, or to the retort getting cracked; and if upon raising the heat sufficiently no bubbles appear, it is a proof that the apparatus has become defective, and that it is needless to continue the operation. In fact, the great nicety in distilling phosphorus lies in the management of the fire, which must be incessantly watched, and fed by the successive introduction of fuel, consisting of coke with a mixture of dry wood and coal.

We may infer that the process approaches its conclusion by the increasing slowness with which gas is disengaged under a powerful heat; and when it ceases to come over, we may cease firing, taking care to prevent reflux of water into the retort, from condensation of its gaseous contents, by admitting air into it through a recurved glass tube, or through the lute of the copper adopter.

The usual period of the operation upon the great scale is from 24 to 30 hours. Its theory is very obvious. The charcoal at an elevated temperature disoxygenates the phosphoric acid with the production of carbonic acid gas at first, and afterwards carbonic oxyde gas, along with sulphureted, carbureted, and phosphureted hydrogen, from the reaction of the water present in the charcoal upon the other ingredients.

The phosphorus falls down in drops, like melted wax; and concretes at the bottom of the water in the receiver. It requires to be purified by squeezing in a shamoy leather bag, while immersed under the surface of warm water, contained in an earthen pan. Each bag must be firmly tied into a ball form, of the size of the fist, and compressed, under the water heated to 130°, by a pair of flat wooden pincers, like those with which oranges are squeezed.

The purified phosphorus is moulded for sale into little cylinders, by melting it at the bottom of a deep jar filled with water, then plunging the wider end of a slightly tapering but straight glass tube into the water, sucking this up to the top of the glass, so as to warm it, next immersing the end in the liquid phosphorus, and sucking it up to any desired height.

The tube being now shut at bottom by the application of the point of the left index, may be taken from the mouth and transferred into a pan of cold water to congeal the phosphorus; which then will commonly fall out of itself, if the tube be nicely tapered, or may at any rate be pushed out with a stiff wire. Were the glass tube not duly warmed before sucking up the phosphorus, this would be apt to congeal at the sides, before the middle be filled, and thus form hollow cylinders, very troublesome and even dangerous to the makers of phosphoric match-bottles. The moulded sticks of phosphorus are finally to be cut with scissors under water to the requisite lengths, and put up in vials of a proper size; which should be filled up with water, closed with ground stoppers, and kept in a dark place. For carriage to a distance, each vial should be wrapped in paper, and fitted into a tin-plate case.

Phosphorus has a pale yellow color, is nearly transparent, brittle when cold, soft and pliable, like wax, at the temperature of 70° F., crystallizing in rhombo-dodecahedrons out of its combination with sulphur, and of specific gravity 1·77. It exhales white fumes in the air, which have a garlic smell, appear luminous in the dark, and spontaneously condense into liquid phosphorous acid. Phosphorus melts in close vessels, at 95° F., into an oily-looking colorless fluid, begins to evaporate at 217·5°, boils at 554°, and if poured in the liquid state into ice-cold water, it becomes black, but resumes its former color when again melted and slowly cooled. It has an acrid disagreeable taste, and acts deleteriously in the stomach, though it has been administered as a medicine by some of the poison-doctors of the present day. It takes fire in the open air at the temperature of 165°, but at a lower degree if partially oxydized, and burns with great vehemence and splendor.

Inflammable match-boxes (*briquets phosphoriques*) are usually prepared by putting into a small vial of glass or lead a bit of phosphorus, and oxydizing it slightly by stirring it round with a redhot iron wire. The vial should be unstoppered only at the instant of plunging into it the tip of the sulphur match which we wish to kindle. Bendix has given the following recipe for charging such match-vials. Take one part of fine dry cork raspings, one part of yellow wax, eight parts of petroleum, and four of phosphorus, incorporate them by fusion, and when the mixture has concreted by cooling, it is capable of kindling a sulphur match dipped into it. Phosphorus dissolves in fat oils, forming a solution luminous in the dark at ordinary temperatures. A vial half filled with this oil, being shaken and suddenly uncorked, will give light enough to see the dial of a watch by night.

There are five combinations of phosphorus and oxygen:—1. the white oxyde; 2. the red oxyde; 3. hypophosphorous acid; 4. phosphorous acid; 5. phosphoric acid. The last is the only one of interest in the arts. It may be obtained from the sirupy superphosphate of lime above described, by diluting it with water, saturating with carbonate of ammonia; evaporating, crystallizing, and gently igniting the salt in a retort. The ammonia is volatilized, and may be condensed into water by a Woulfe's apparatus, while the phosphoric acid remains in the bottom of the retort. Phosphoric acid may be more readily produced by burning successive bits of phosphorus in a silver saucer, under a great bell jar inverted upon a glass plate, so as to admit a little air to carry on the combustion. The acid is obtained in a fine white snowy deposite; consisting, in this its dry state, of 44 of phosphorus and 56 of oxygen. That obtained from the sirupy solution is a hydrate, and contains 9·44 per cent. of water. If the atom of phosphorus be called 32 upon the hydrogen radix, then 5 atoms of oxygen = 40 will be associated with it in the dry acid, = 72; and an additional atom of water = 9, in the hydrate, will make its prime equivalent 81. Phosphorous acid seems to contain no more than 3 atoms of oxygen.

The only salts of this acid much in demand, are the phosphate of soda, and the ammonia phosphate of soda. The former is prepared by slightly supersaturating superphosphate of lime with crystals of carbonate of soda; warming the solution, filtering, evaporating, and crystallizing. It is an excellent purgative, and not unpalatable. The triple phosphate is used in docimastic operations; and is described under METALLURGY.

PICAMARE, is a thick oil, one of the six new principles detected by M. Reichenbach, in wood-tar. See CREOSOTE and PARAFFINE. Picamare constitutes 1-6th of beech-tar.

PICROMEL, is the name given by M. Thenard to a black bitter principle which he supposed to be peculiar to the bile. MM. Gmelin and Tiedemann have since called its identity in question.

PICROTOXINE, is an intensely bitter poisonous vegetable principle, extracted from the seeds of the *Menispermum cocculus*, (Cocculus Indicus). It crystallizes in small white needles, or columns; dissolves in water and alcohol. It does not combine with acids, but with some bases, and is not, therefore, of an alkaline nature, as had been at first supposed.

PIGMENTS, VITRIFIABLE, belong to five different styles of work: 1. to enamel painting; 2. to painting on metals; 3. to painting on stoneware; 4. to painting on porcelain; 5. to stained glass.

PIMENTO (*Myrtus pimenta*, or Jamaica pepper) consists, according to Bonastre's complicated analysis, of—

	Shells or capsules.	Kernels.
Volatile oil	10·0	5·0
Soft green resin	8·0	2·5
Fatty concrete oil	0·9	1·2
Extract containing tannin	11·4	39·8
Gum	3·0	7·2
Brown matter dissolved in potash	4·0	8·0
Resinoid matter	1·2	3·2
Extract containing sugar	3·0	8·0
Gallic and malic acids	0·6	1·6
Vegetable fibre	50·0	16·0
Ashes charged with salts	2·8	1·9
Moisture and loss	4·1	4·8

Pimento imported for home consumption, in 1835. 1836.
Duty—British possessions, 5*d.*; foreign, 1*s.* 3*d.* Lbs. 344,458. 400,914.

PINCHBECK is a modification of brass; see that article and COPPER.

PINE-APPLE YARN and CLOTH. In Mr. Zincke's process, patented in December, 1836, for preparing the filaments of this plant, the *Bromelia ananas*, the leaves being plucked, and deprived of the prickles round their edges by a cutting instrument, are then beaten upon a wooden block with a wooden mallet, till a silky-looking mass of fibres be obtained, which are to be freed by washing from the green fecula. The fibrous part must next be laid straight, and passed between wooden rollers. The leaves should be gathered between the time of their full maturity and the ripening of the fruit. If earlier or later, the fibres will not be so flexible, and will need to be cleared by a boil in soapy water for some hours; after being laid straight under the pressure of a wooden grating, to prevent their becoming entangled. When well washed and dried, with occasional shaking out, they will now appear of a silky fineness. They may be then spun into porous rovings, in which state they are most conveniently bleached by the ordinary methods.

Specimens of cambric, both bleached and unbleached, woven with these fibres, have been recently exhibited, which excited hopes of their rivalling the finest flax fabrics, but in my opinion without good reason, on account of their want of strength.

PINEY TALLOW is a concrete fat obtained by boiling with water the fruit of the *Vateria indica*, a tree common upon the Malabar coast. It seems to be a substance intermediate between tallow and wax; partaking of the nature of stearine. It melts at 97½° F., is white or yellowish, has a spec. grav. of 0·926; is saponified by alkalis, and forms excellent candles. Dr. Benjamin Babington, to whom we are indebted for all our knowledge of piney tallow, found its ultimate constituents to be, 77 of carbon, 12·3 of hydrogen, and 10·7 of oxygen.

PIN MANUFACTURE. (*Fabrique d'épingles*, Fr.; *Nadelfabrik*, Germ.) A pin is a small bit of wire, commonly brass, with a point at one end, and a spherical head at the other. In making this little article, there are no less than fourteen distinct operations.

1. *Straightening the wire.* The wire, as obtained from the drawing-frame, is wound about a bobbin or barrel, about 6 inches diameter, which gives it a curvature that must be removed. The straightening engine is formed by fixing 6 or 7 nails upright in a waving line on a board, so that the void space measured in a straight line between the first three nails may have exactly the thickness of the wire to be trimmed; and that the other nails may make the wire take a certain curve line, which must vary with its thickness. The workman pulls the wire with pincers through among these nails, to the length of about 30 feet, at a running draught; and after he cuts that off, he returns for as much more; he can thus finish 600 fathoms in the hour. He next cuts these long pieces into lengths of 3 or 4 pins. A day's work of one man amounts to 18 or 20 thousand dozen of pin-lengths.

2. *Pointing* is executed on two iron or steel grindstones, by two workmen, one of whom roughens down, and the other finishes. Thirty or forty of the pin wires are applied to the grindstone at once, arranged in one plane, between the two forefingers and thumbs of both hands, which dexterously give them a rotatory movement.

3. *Cutting these wires into pin-lengths.* This is done by an adjusted chisel. The intermediate portions are handed over to the *pointer.*

4. *Twisting of the wire for the pin-heads.* These are made of a much finer wire, coiled into a compact spiral, round a wire of the size of the pins, by means of a small lathe constructed for the purpose.

5. *Cutting the heads.* Two turns are dexterously cut off for each head, by a regulated chisel. A skilful workman may turn off 12,000 in the hour.

6. *Annealing the heads.* They are put into an iron ladle, made redhot over an open fire, and then thrown into cold water.

7. *Stamping or shaping the heads.* This is done by the blow of a small ram, raised by means of a pedal lever and a cord. The pin-heads are also fixed on by the same operative, who makes about 1500 pins in the hour, or from 12,000 to 15,000 per diem; exclusive of one thirteenth, which is always deducted for waste in this department, as well as in the rest of the manufacture. Cast heads, of an alloy of tin and antimony, were introduced by patent, but never came into general use.

8. *Yellowing or cleaning the pins* is effected by boiling them for half an hour in sour beer, wine lees, or solution of tartar; after which they are washed.

9. *Whitening or tinning.* A stratum of about 6 pounds of pins is laid in a copper pan, then a stratum of about 7 or 8 pounds of grain tin; and so alternately till the vessel be filled; a pipe being left inserted at one side, to permit the introduction of water slowly at the bottom, without deranging the contents. When the pipe is withdrawn, its space is filled up with grain tin. The vessel being now set on the fire, and the water becoming hot, its surface is sprinkled with 4 ounces of cream of tartar; after which it is allowed to boil for an hour. The pins and tin grains are, lastly, separated by a kind of cullender.

10. *Washing the pins* in pure water.

11. *Drying and polishing them,* in a leather sack filled with coarse bran, which is agitated to and fro by two men.

12. *Winnowing,* by fanners.

13. *Pricking the papers* for receiving the pins.

14. *Papering,* or fixing them in the paper. This is done by children, who acquire the habit of putting up 36,000 per day.

The pin manufacture is one of the greatest prodigies of the division of labor; it furnishes 12,000 articles for the sum of three shillings, which have required the united diligence of fourteen skilful operatives.

The above is an outline of the mode of manufacturing pins by hand labor, but several beautiful inventions have been employed to make them entirely or in a great measure by machinery; the consumption for home sale and export amounting to 15 millions daily, for this country alone. One of the most elaborate and apparently complete is that for which Mr. L. W. Wright obtained a patent in May, 1824. A detailed description of it will be found in the 9th volume of Newton's London Journal. The following outline will give my readers an idea of the structure of this ingenious machine:—

The rotation of a principal shaft, mounted with several cams, gives motion to various sliders, levers, and wheels, which work the different parts. A slider pushes pincers forwards, which draw wire from a reel, at every rotation of the shaft, and advance such a length of wire as will produce one pin. A die cuts off the said length of wire by the descent of its upper chap; the chap then opens a carrier, which takes the pin to the pointing apparatus. Here it is received by a holder, which turns round, while a beveledged file-wheel rapidly revolves, and tapers the end of the wire to a point. The pin is now conducted by a second carrier to a finer file-wheel, in order to finish the point by a second grinding. A third carrier then transfers the pin to the first heading die, and by the advance of a steel punch, the end of the pin wire is forced into a recess, whereby the head is partially swelled out. A fourth carrier removes the pin to a second die, where the heading is perfected. When the heading-bar retires, a forked lever draws the finished pin from the die, and drops it into a receptacle below.

I believe the chief objection to the raising of the heads by strong mechanical compression upon the pins, is the necessity of softening the wire previously; whereby the pins thus made, however beautiful to the eye, are deficient in that stiffness which is so essential to their employment in many operations of the toilet.

PIPERINE is a crystalline principle extracted from black pepper by means of alcohol. It is colorless, has hardly any taste, fuses at 212° F.; is insoluble in water, but soluble in acetic acid, ether, and most readily in alcohol.

PITCH, MINERAL, is the same as Bitumen and Asphalt.

PITCH *of wood-tar* (*Poix*, Fr.; *Pech*, Germ.) is obtained by boiling tar in an open iron pot, or in a still, till the volatile matters be driven off. Pitch contains pyroligneous resin, along with colophany (common rosin), but its principal ingredient is the former, called by Berzelius pyretine. It is brittle in the cold, but softens and becomes ductile with heat. It melts in boiling water, and dissolves in alcohol and oil of turpentine, as well as in carbonated or caustic alkaline leys. For PYRETINE, see the mode of preparing it from birch wood, for the purpose of preparing *Russia* LEATHER.

PITCOAL. (*Houille*, Fr.; *Steinkohle*, Germ.) This is by far the most valuable of mineral treasures, and the one which, at least in Great Britain, makes all the others available to the use and comfort of man. Hence it has been searched after with unremitting diligence, and worked with all the lights of science, and the resources of art.

The Brora coal-field in Sutherlandshire is the most remarkable example in this, or in perhaps any country hitherto investigated, of a pseudo coal-basin among the deeper secondary strata, but above the new sandstone or red marl formation. The Rev. Dr. Buckland and Mr. C. Lyell, after visiting it in 1824, had expressed an opinion that the strata there were wholly unconnected with the proper coal formation below the new red sandstone, and were in fact the equivalent of the oolitic series; an opinion fully confirmed by the subsequent researches of Mr. Murchison. (*Geol. Trans.* for 1827, p. 293.) The Brora coal-field forms a part of those secondary deposites which range along the south-east coast of Sutherlandshire, occupying a narrow tract of about twenty miles in length, and three in its greatest breadth.

One stratum of the Brora coal-pit is a coal-shale, composed of a reed-like striated plant of the natural order *Equisetum*, which seems to have contributed largely towards the formation of that variety of coal. From this coal-shale, the next transition upwards is into a purer bituminous substance approaching to *jet*, which constitutes the great bed of coal. This is from 3 feet 3 inches to 3 feet 8 inches thick, and is divided nearly in the middle by a thin layer of impure indurated shale charged with pyrites, which, if not carefully excluded from the mass, sometimes occasions spontaneous combustion upon exposure to the atmosphere; and so much, indeed, is that mineral disseminated throughout the district, that the shales might be generally termed "pyritiferous." Inattention on the part of the workmen, in 1817, in leaving a large quantity of this pyritous matter to accumulate in the pit, occasioned a spontaneous combustion, which was extinguished only by excluding the air; indeed, the coal-pit was closed in and remained unworked for four years. The fires broke out again in the pit in 1827.

The purer part of the Brora coal resembles common pitcoal; but its powder has the red ferruginous tinge of pulverized lignites. It may be considered one of the last links between lignite and true coal, approaching very nearly in character to jet, though less tenacious than that mineral; and, when burnt, exhaling but slightly the vegetable odor so peculiar to all imperfectly bituminized substances. The fossil remains of shells and plants prove the Brora coal to be analogous to that of the eastern moorlands of Yorkshire, although the extraordinary thickness of the former, compared with any similar deposite of the latter (which never exceeds from 12 to 17 inches), might have formerly led to the belief that it was a detached and anomalous deposite of true coal, rather than a lignite of any of the formations *above* the new red sandstone: such misconception might more easily arise in the infancy of geology, when the strata were not identified by their fossil organic remains.

On the coast of Yorkshire the strata of this pseudo coal formation appear in the following descending order, from Filey Bay to Whitby. 1. Coral-rag. 2. Calcareous grit. 3. Shale, with fossils of the Oxford clay. 4. Kelloway rock (swelling out into an important arenaceous formation). 5. Cornbrash. 6. Coaly grit of Smith. 7. Pierstone (according to Mr. Smith, the equivalent of the great oolite). 8. Sandstone and shale, with *peculiar plants and various seams of coal.* 9. A bed with fossils of the inferior oolite. 10. Marl-stone? 11. Alum-shale or lias. All the above strata are identified by abundant organic remains.

In the oolitic series, therefore, where the several strata are developed in conformity with the more ordinary type of these formations, we may venture to predict with certainty, that no carboniferous deposites of any great value will ever be discovered, at all events in Great Britain. A want of such knowledge has induced many persons to make trials for coal in beds subordinate to the English oolites, and even superior to them, in places where the type of formation did not offer the least warrant for such attempts.

The third great class of terrestrial strata, is the proper coal-measures, called the *carboniferous rocks*, our leading object here, and to which we shall presently return.

The transition rocks which lie beneath the coal-measures, and above the primitive rocks, or are anterior to the carboniferous order, and posterior to the primitive, contain a peculiar kind of coal, called anthracite or stone-coal, approaching closely in its nature to carbon. It is chiefly in the transition clay-slate that the anthracite occurs in considerable masses. There is one in the transition slate of the little Saint Bernard, near the village of *la Thuile* (in the Alps). It is 100 feet long, and 2 or 3 yards thick.

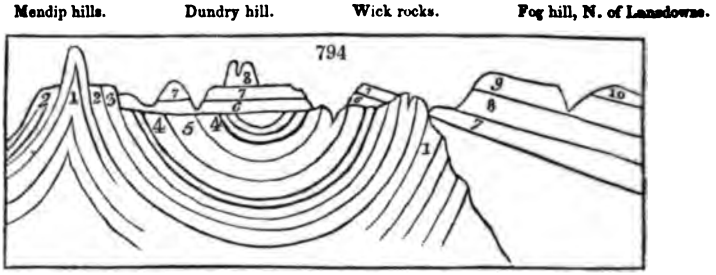
The coal burns with difficulty, and is used only for burning lime. There are several of the same kind in that country, which extend down the reverse slope of the mountains looking to Savoy. The slate enclosing them presents vegetable impressions of reeds or analogous plants. To the transition clay-slate we must likewise refer the beds of anthracite that M. Hericart de Thury observed at very great heights in the Alps of Dauphiny, in a formation of schist and gray-wacke with vegetable impressions, which reposes directly on the primitive rocks.

The great carboniferous formation may be subdivided into four orders of rocks: 1. the coal-measures, including their manifold alternations of coal-beds, sandstones, and shales; 2. the millstone grit and shale towards the bottom of the coal measures; 3. the carboniferous limestone, which projecting to considerable heights above the outcrop of the coal and grit, acquires the title of mountain limestone; 4. the old red sandstone, or connecting link with the transition and primary rock basin in which the coal system lies.

The coal-fields of England, from geographical position, naturally fall under the following arrangement:—1. The *great northern district;* including all the coal-fields north of Trent. 2. The *central district;* including Leicester, Warwick, Stafford, and Shropshire. 3. The *western district;* subdivided into *north-western*, including North Wales, and the *south-western*, including South Wales, Gloucester, and Somersetshire.

There are three principal coal-basins in Scotland: 1. that of Ayrshire; 2. that of Clydesdale; and 3. that of the valley of the Forth, which runs into the second in the line of the Union Canal. If two lines be drawn, one from Saint Andrews on the north-east coast, to Kilpatrick on the Clyde, and another from Aberlady, in Haddingtonshire, to a point a few miles south of Kirkoswald in Ayrshire, they will include between them the whole space where pitcoal has been discovered and worked in Scotland.

The great coal-series consists of a regular alternation of mineral strata deposited in a great concavity or basin, the sides and bottom of which are composed of transition rocks. This arrangement will be clearly understood by inspecting *fig.* 794, which represents a section of the coal-field south of Malmsbury.



1, 1, old red sandstone; 2, mountain limestone; 3, millstone grit; 4, 4, coal seams; 5, Pennant, or coarse sandstone; 6, new red sandstone, or red marl; 7, 7, lias; 8, 8, inferior oolite; 9, great oolite; 10, cornbrash and Forest marble.

No. 1, or the old red sandstone, may therefore be regarded as the characteristic lining of the coal basins; but this sandstone rests on transition limestone, and this limestone on gray-wacke. This methodical distribution of the carboniferous series is well exemplified in the coal-basin of the Forest of Dean in the south-west of England, and has been accurately described by Mr. Mushet.

The *gray-wacke* consists of highly inclined beds of slaty micaceous sandstone, which on the one hand alternates with and passes into a coarse breccia, having grains as large as peas; on the other, into a soft argillaceous slate. The gray-wacke stands bare on the north-eastern border of the Forest, near the southern extremity of the chain of transition limestone, which extends from Stoke Edith, near Hereford, to Flaxley on the Severn. It is traversed by a defile, through which the road from Gloucester to Ross winds. The abruptness of this pass gives it a wild and mountainous character, and affords the best opportunity of examining the varieties of the rock.

The *Transition limestone* consists in its *lower beds* of fine-grained, tender, extremely argillaceous slate, known in the district by the name of *water-stone*, in consequence of the wet soil that is found wherever it appears at the surface. Calcareous matter is interspersed in it but sparingly. Its *upper beds* consist of shale alternating with extensive beds of stratified limestone. The lowest of the calcareous strata are thin, and alternate with shale. On these repose thicker strata of more compact limestone, often of a dull blue color. The beds are often dolomitic, which is indicated by straw yellow color, or dark pink color, and by the sandy or glimmering aspect of the rock.

The *old red sandstone*, whose limits are so restricted in other parts of England, here occupies an extensive area. The space which it covers, its great thickness, its high inclination, the abrupt character of the surface over which it prevails, and the consequent display of its strata in many natural sections, present in this district advantages for studying the formation, which are not to be met with elsewhere in South Britain. In the neighborhood of Mitchel Dean, the total thickness of this formation, interposed conformably between the transition and mountain limestone, is from 600 to 800 fathoms. The old red sandstone is characterized in its upper portion by the presence of silicious conglomerate, containing silicious pebbles, which is applied extensively to the fabrication of millstones near Monmouth, and on the banks of the Wye. This sandstone encircles the Forest with a ring of very elevated ground, whose long and lofty ridges on the eastern frontier overhang the valley of the Severn.

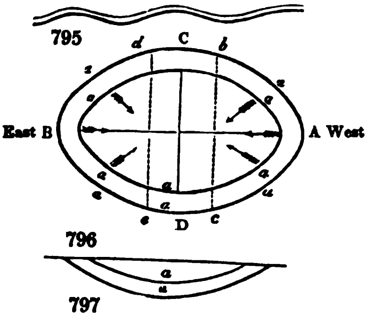
The *mountain limestone*, or carboniferous, is distinguished from transition limestone, rather by its position than by any very wide difference in its general character or organic remains. According to the measurements of Mr. Mushet, the total thickness of the mountain limestone is about 120 fathoms. The zone of limestone belonging to this coal-basin, is from a furlong to a mile in breadth on the surface of the ground, according as the dip of the strata is more or less rapid. The angle of dip on the northern and western border is often no more than 10°, but on the eastern it frequently amounts to 80°. The calcareous zone that defines the outer circle of the basin, suffers only one short interruption, scarcely three miles in length, where in consequence of a fault the limestone disappears, and the coal-measures are seen in contact with the old red sandstone.

Coal measures.—Their aggregate thickness amounts, according to Mr. Mushet, to about 500 fathoms. 1. The lowest beds, which repose on the mountain limestone, are about 40 fathoms thick, and consist here, as in the Bristol coal-basin, of a red silicious grit, alternating with conglomerate, used for millstones; and with clay, occasionally used for ochre. 2. These beds are succeeded by a series about 120 fathoms thick, in which a gray gritstone predominates, alternating in the lower part with shale, and containing 6 seams of coal. The grits are of a fissile character, and are quarried extensively for flag-stone, ashlers, and fire-stone. 3. A bed of grit, 25 fathoms thick, quarried for hearth-stone, separates the preceding series from the following, or the 4th, which is about 115 fathoms thick, and consists of from 12 to 14 seams of coal alternating with shale. 5. To this succeeds a straw-colored sandstone, nearly 100 fathoms thick, forming a high ridge in the interior of the basin. It contains several thin seams of coal, from 6 to 16 inches in thickness. 6. On this reposes a series of about 12 fathoms thick, consisting of 3 seams of coal alternating with shale. 7. This is covered with alternate beds of grit and shale, whose aggregate thickness is about 100 fathoms, occupying a tract in the centre of the basin about 4 miles long, and 2 miles broad. The sandstone No. 5 is probably the equivalent of the Pennant in the preceding figure.

The floor, or pavement, immediately under the coal beds is, almost without exception, a grayish slate-clay, which, when made into bricks, strongly resists the fire. This fire-clay varies in thickness from a fraction of an inch to several fathoms. Clay-ironstone is often disseminated through the shale.

The most complete and simplest form of a coal-field is the entire basin-shape, which we find in some instances without a dislocation. A beautiful example of this is to be seen at Blairengone, in the county of Perth, immediately adjoining the western boundary of Clackmannanshire, as represented in *fig.* 795, where the outer elliptical line, marked A, B, C, D, represents the crop, outburst, or basset edge of the lower coal, and the inner elliptical line represents the crop or basset edge of the superior coal. *Fig.* 796 is the

795



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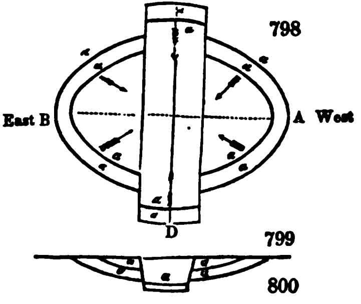

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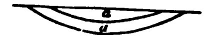

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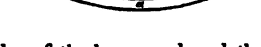

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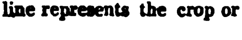

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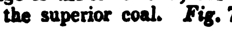


longitudinal section of the line A B; and *fig.* 797, the transverse section of the line C D. All the accompanying coal strata partake of the same form and parallelism. These basins are generally elliptical, sometimes nearly circular, but are often very eccentric, being much greater in length than in breadth; and frequently one side of the basin on the short diameter has a much greater dip than the other, which circumstance throws the trough or lower part of the basin concavity much nearer to the one side than to the other. From this view of one entire basin, it is evident that the dip of the coal strata belonging to it runs in opposite directions, on the opposite sides, and that all the strata regularly crop out, and meet the alluvial cover in every point of the circumferential space, like the edges of a nest of common basins. The waving line marks the river Devon.

It is from this basin shape that all the other coal-fields are formed, which are segments of a basin produced by slips, dikes, or dislocations of the strata. If the coals (*fig.* 795) were dislocated by two slips *b c* and *d e*, the slip *b c* throwing the strata *down* to the east, and the slip *d e* throwing them as much *up* in the same direction, the outcrops of the coals would be found in the form represented in *fig.* 798, of which *fig.* 799 is the section in the line A B, and *fig.* 800 the section in the line C D.

The chief difficulty in exploring a country in search of coal, or one where coal-fields are known to exist, arises from the great thickness of alluvial and other cover, which completely hides the outcrop or basset edge of the strata, called by miners the *rock-head;* as also the fissures, dikes, and dislocations of the strata, which so entirely change the structure and bearings of coal-fields, and cause often great loss to the mining adventurer. The alluvial cover on the other hand is beneficial, by protecting the seams of the strata from the superficial waters and rains, which would be apt to drown them, if they were naked. In all these figures of coal-basins, the letter *a* indicates coal.

The absolute shape of the coal-fields in Great Britain has been ascertained with surprising precision. To whatever depth a coal-mine is drained of its water, from that depth it is worked, up to the rise of the water-level line, and each miner continues to advance his room or working-place, till his seam of coal meets the alluvial cover of the outcrop, or is cut off by a dislocation of the strata. In this way the miner travels in succession over every point of his field, and can portray its basin-shape most minutely.

801

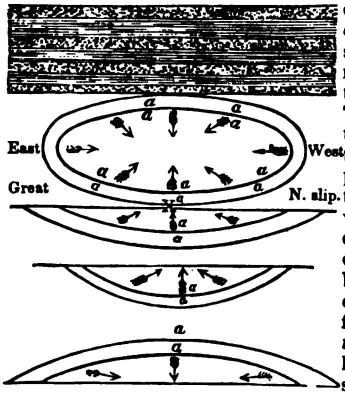


Fig. 801 represents a horizontal plan of the Clackmannanshire coal-field, as if the strata at the outcrop all around were denuded of the alluvial cover. Only two of the concentric beds, or of their edges *a*, *a*, are represented, to avoid perplexity. It is to be remembered, however, that all the series of attendant strata lie parallel to the above lines. This plan shows the Ochill mountains, with the north coal-fields, of an oblong elliptical shape, the side of the basin next the mountains being precipitous, as if upheaved by the eruptive trap-rocks; while the south, the east, and the west edges of the basin shelve out at a great distance from the lower part of the concavity or *trough*, as miners call it. Thus the alternate beds of coal, shale, and sandstone, all nearly concentric in the north coal-field, dip inwards from all sides towards the central area of the *trough*. The middle coal-field of this district, however, which is formed by the great north slip, is merely the segment of an elliptical basin, where the strata dip in every direction to the middle of the axis marked with the letter x; being the deepest part of the segment. The south coal-field, formed by the great south slip, is likewise the segment of another elliptical basin, similar in all respects to the middle coal-field. Beyond the outcrop of the coals and subordinate strata of the south coal-fields, the counter dip of the strata takes place, producing the mantle-shaped form; whence the coal strata in the Dunmore field, in Stirlingshire, lie in a direction contrary to those of the south coal-field of Clackmannanshire. o, are the Ochill mountains.

Fig. 802 is intended to represent an extensive district of country, containing a great coal-basin, divided into numerous subordinate coal-fields by these dislocations. The lines marked *b* are slips, or faults; the broad lines marked *c* denote dikes; the former dislocate the strata, and change their level, while dikes disjoin the strata with a wall, but do not in general affect their elevation. The two parallel lines marked *a*, represent two seams of coal, variously heaved up and down by the faults; whereas the dikes are seen to pass through the strata without altering their relative position. In this manner, partial coal-fields are distributed over a wide area of country, in every direction.

The only exception to this general form of the coal-fields in Great Britain, is the inrted basin shape; but this is rare. A few examples occur in some districts of Engid, and in the county of Fife; but even in extensive coal-fields, this convex form is t a partial occurrence, or a deviation by local violence from the ordinary basin. ;. 803 is an instance of a convex coal-field exhibited in Staffordshire, at the Castle-hill, close to the town of Dudley. 1, 1, are limestone strata; 2, 2, are coal. Through this hill, canals have been cut, for working the immense beds of carboniferous limestone. These occur in the lower series of the strata of the coal-field, and therefore at a distance of many miles from the Castle-hill, beyond the outcrop of all the workable coals in the proper basin-shaped part of the field; but by this apparently inverted basin-form, these limestone beds are elevated far above the level of the general surface of the country, and consequently above the level of all the coals. We must regard this seeming inversion as resulting from the approximation of two coal-basins, separated by the basset edges of their mountain limestone repository.

802

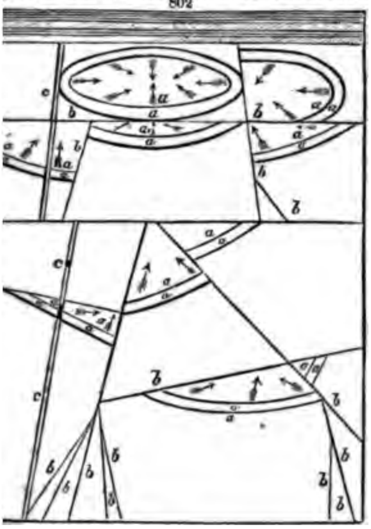


Fig. 804 is a vertical section of the Dudley coal-basin, the upper coal-bed of which has the astonishing thickness of 30 feet; and this mass extends 7 miles in length, and 4 in breadth. Coal-seams 5 or 6 feet thick, are called *thin* in that district.

803

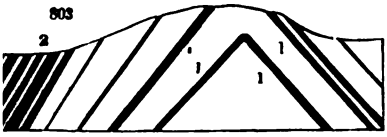
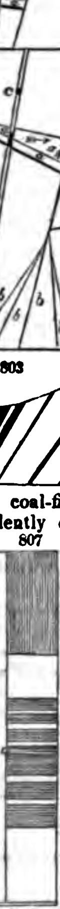


Fig. 805 is a very interesting section of the main coal-basin of Clackmannanshire, as given by Mr. Bald in the Wernerian Society's Memoirs, vol. iii. Here we see it broken into three sub- inate coal-fields, formed by two great faults or dislocations of the strata; but ependently of these fractures across the whole series, the strata continue quite regular in their respective alternations, and preserve nearly unchanged their angle of inclination to the horizon. The section shows the south coal-field dipping northerly, till it is cut across by the great south slip *x*, which dislocates the coal and the parallel strata to the enormous extent of 1230 feet, by which all the coals have been thrown up, not simply to the day, but are not found again till we advance nearly a mile northward, on the line of the dip, where the identical seams of coal, shale, &c. are observed once more with their regular inclination. These coals of the middle area, dip regularly northward till interrupted by the great north slip *y*, which dislocates the strata, and throws them up 700 feet; that is to say, a line prolonged in the direction of any one well-known seam, will run 700 feet above the line of the same seam as it emerges after the middle slip. Immediately adjoining the north slip, the coals and coal-field resume their course, and dip regularly northward, running through a longer range than either of the other two members of the basin, till they arrive at the valley of the Devon, at the foot of the Ochill mountains, where they form a concave curvature, or trough, *a*, and thence rise rapidly in an almost vertical direction at *b*. Here the coals, h all their associate strata, assume conformity and parallelism with the face of the itic-greenstone strata of the Ochill mountains *c*; being raised to the high angle of 73 rees with the horizon. The coal-seams thus upheaved, are called *edge-metals* by the ers.

04

807



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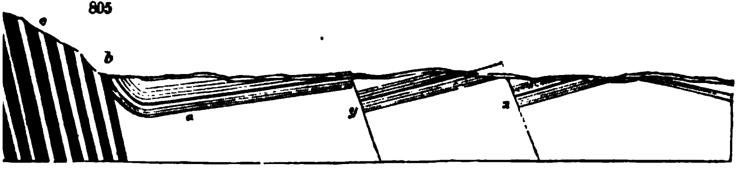
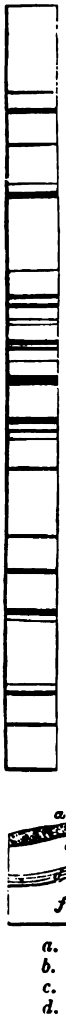


In this remarkable coal-field, which has been accurately explored by pitting and boring to the depth of 703 feet, there are no fewer than 142 beds, or distinct strata of coal, shale, and sandstone, &c., variously alternating, an idea of which may be had by inspecting *fig.* 806. Among these are 24 beds of coal, which would constitute an aggregate thickness of 59 feet 4 inches; the thinnest seam of coal being 2 inches, and the thickest 9 feet. The strata of this section contain numerous varieties of sandstone, slate-clay, bituminous shale, indurated clay, or fire-clay, and clay ironstone. Neither trap-rock nor limestone is found in connexion with the workable coals; but an immense bed of greenstone, named Abbey Craig, occurs in the western boundary of Clackmannanshire, under which lie regular strata of slate-clay, sandstone, thin beds of limestone, and large spheroidal masses of clay ironstone, with a mixture of lime.

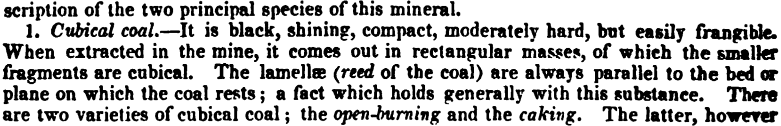
806



"With regard to slips in coal-fields," says Mr. Bald, "we find that there is a general law connected with them as to the position of the dislocated strata, which is this:—When a slip is met with in the course of working the mines—if when looking to it, the vertical line of the slip or fissure, it forms an acute angle with the line of the pavement upon which the observer stands, we are certain that the strata are dislocated downwards upon the other side of the fissure. On the contrary, if the angle formed by the two lines above mentioned is obtuse, we are certain that the strata are dislocated or thrown upwards upon the other side of the fissure. When the angle is 90°, or a right angle, it is altogether uncertain whether the dislocation throws up or down on the opposite side of the slip. When dikes intercept the strata, they generally only separate the strata the width of the dike, without any dislocation, either up or down; so that if a coal is intercepted by a dike, it is found again by running a mine directly forward, corresponding to the angle or inclination of the coal with the horizon."—*Wernerian Society's Memoirs*, vol. iii. p. 133.*

The Johnstone coal-field, in Renfrewshire, is both singular and interesting. The upper stratum of rock is a mass of compact greenstone or trap, above 100 feet in thickness, not at all in a conformable position with the coal strata, but overlying; next there are a few fathoms of soft sandstone and slate-clay, alternating, and uncommonly soft Beneath these beds, there are no fewer than ten seams of coal, lying on each other, with a few divisions of dark indurated clay. These coal-seams have an aggregate thickness of no less than 100 feet; a mass of combustible matter, in the form of coal, unparalleled for its accumulation in so narrow a space. The greater part of this field contains only 5 beds of coal; but at the place where the section shown in *fig.* 807 is taken, these five coals seem to have been overlapped or made to slide over each other by violence. This structure is represented in *fig.* 808, which is a section of the Quarrelton coal in the Johnstone field, showing the overlapped coal and the double coal, with the thick bed of greenstone, overlying the coal-field.

808



a. Alluvial cover.
b. Bed of trap or greenstone.
c. Alternating coal strata.
d. Coal-seams.
e. Position of greenstone, not ascertained.
f. Strata in which no coals have been found.
g. The overlapped coal.
h. The double coal.

Before proceeding to examine the modes of working coal, I shall introduce here a description of the two principal species of this mineral.

1. *Cubical coal.*—It is black, shining, compact, moderately hard, but easily frangible. When extracted in the mine, it comes out in rectangular masses, of which the smaller fragments are cubical. The lamellæ (*reed* of the coal) are always parallel to the bed or plane on which the coal rests; a fact which holds generally with this substance. There are two varieties of cubical coal; the *open-burning* and the *caking*. The latter, however small its fragments may be, is quite available for fuel, in consequence of its agglutinating into a mass at a moderate heat, by the abundance of its bitumen. This kind is the true smithy or forge-coal, because it readily forms itself into a vault round the blast of the bellows, which serves for a cupola in concentrating the heat on objects thrust into the cavity.

The open-burning cubical coals are known by several local names; the rough coal or eoal, from the large masses in which they may be had and the cherry coal, from heerful blaze with which they spontaneously burn; whereas the caking coals, such ost of the Newcastle qualities, require to be frequently poked in the grate. Its speci- avity varies from 1·25 to 1·4.

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* This paper does honor to its author, the eminent coal-viewer of Scotland.

Slate or splint coal.—This is dull-black, very compact, much harder, and more ultly frangible than the preceding. It is readily fissile, like slate, but powerfully ts the cross fracture, which is conchoidal. Specific gravity from 1·26 to 1·40. In ing, it separates in large quadrangular sharp-edged masses. It burns without ig, produces much flame and smoke, unless judiciously supplied with air, and leaves ently a considerable bulk of white ashes. It is the best fuel for distilleries and all grates, as it makes an open fire, and does not clog up the bars with glassy scoriæ. nd good splint coal of the Glasgow field to have a specific gravity of 1·266, and to ist of—carbon, 70·9; hydrogen, 4·3; oxygen, 24·8.

Cannel coal.—Color between velvet and grayish-black; lustre resinous; fracture ; fragments trapezoidal; hard as splint coal; spec. grav. 1·23 to 1·28. In working, letached in four-sided columnar masses, often breaks conchoidal, like pitch, kindles readily, and burns with a bright white projective flame, like the wick of a candle, ice its name. It occurs most abundantly in the coal-field of Wigan, in Lancashire, bed 4 feet thick; and there is a good deal of it in the Clydesdale coal-field, of which ms the lowest seam that is worked. It produces very little dust in the mine, and ly soils the fingers with carbonaceous matter. Cannel coal from Woodhall, near gow, spec. grav. 1·228, consists by my analysis of—carbon, 72·22; hydrogen, 3·93; en, 21·05; with a little azote (about 2·8 in 100 parts.) This coal has been found to d, in the Scotch gas-works, a very rich-burning gas. The azote is there converted ammonia, of which a considerable quantity is distilled over into the tar-pit.

Glance coal.—This species has an iron-black color, with an occasional iridiscence, that of tempered steel; lustre in general splendent, shining, and imperfect metallic; not soil; easily frangible; fracture flat conchoidal; fragments sharp-edged. It burns out flame or smell, except when it is sulphureous; and it leaves a white-colored It produces no soot, and seems, indeed, to be merely carbon, or coal deprived of olatile matter or bitumen, and converted into coke by subterranean calcination, fre- itly from contact with whin-dikes. Glance coal abounds in Ireland, under the name ilkenny coal; in Scotland it is called blind coal, from its burning without flame or te; and in Wales, it is the malting or stone coal. It contains from 90 to 97 per cent. irbon. Specific gravity from 1·3 to 1·5; increasing with the proportion of earthy im- ties.

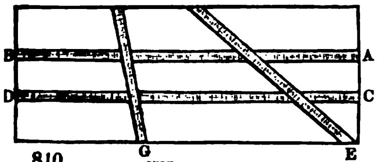
he dislocations and obstructions found in coal-fields, which render the search for coal ifficult, and their mining so laborious and uncertain, are the following:—

Dikes. 2. *Slips or Faults.* 3. *Hitches.* 4. *Troubles.*

he first three infer dislocation of the strata; the fourth changes in the bed of coal itself.

A dike is a wall of extraneous matter, which divides all the beds in a coal-field. ikes extend not only in one line of bearing through coal-fields for many miles, but sometimes in different directions, and have often irregular bendings, but no sharp ilar turns. When from a few feet to a few fathoms in thickness, they occur some- s in numbers within a small area of a coal basin, running in various directions, and crossing each other. *Fig.* 809 represents a ground plan of a coal-field, intersected with greenstone dikes. A B and C D are two dikes standing parallel to each other; E F and G H are cross or oblique dikes, which divide both the coal strata and the primary dikes A B and C D.

809



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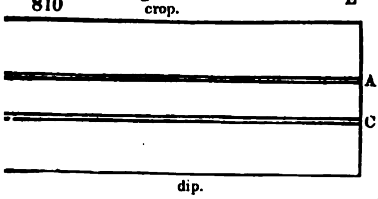
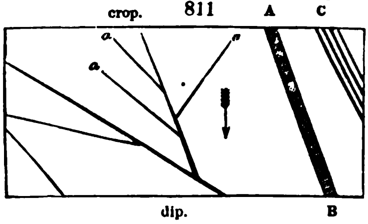


2. *Slips* or *faults* run in straight lines through coal-measures, and at every angle of incidence to each other. *Fig.* 810 represents a ground plan of a coal-field, with two slips A B and C D in the line of bearing of the planes of the strata, which throw them down to the outcrop. This is the simplest form of a slip. *Fig.* 811 exhibits part of a coal-field intersected with slips, like a cracked sheet of ice. Here A B is a dike; while the narrow lines show faults of every kind, producing dislo- ons varying in amount of slip from a few feet to a great many fathoms. The faults he points *a*, *a*, *a* vanish; and the lines at c denote four small partial slips called es.

The effects of slips and dikes on the coal strata appear more prominently when viewed in a vertical section, than in a ground plan, where they seem to be merely walls, veins, and lines of demarcation. *Fig.* 812 is a vertical section of a coal-field, from dip to rise, showing three strata of coal *a*, *b*, *c*. A B represents a dike at right angles to the plane of the coal-beds. This rectangular wall merely separates the coal-measures, affecting their line of rise; but further to the rise, the oblique dike C D interrupts the coals *a*, *b*, *c*, and not only disjoins them, but throws them and their concomitant strata greatly lower down; but still, with this depression, the strata retain their parallelism and general slope. Nearer to the outcrop, another dike E, F, interrupts the coals *a*, *b*, *c*, not merely breaking the continuity of the planes, but throwing them moderately up, so as to produce a steeper inclination, as shown in the figure. It sometimes happens that the coals in the compartment H, betwixt the dikes C and E, may lie nearly horizontal, and the effect of the dike E, F, is then to throw out the coals altogether, leaving no vestige of them in the compartment K. "Such," says Mr. Bald, from whom these illustrations are borrowed, "are the most prominent changes in the strata, as to their line of direction, produced by dikes; but of these changes there are various modifications."

811



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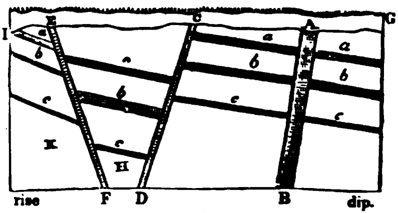
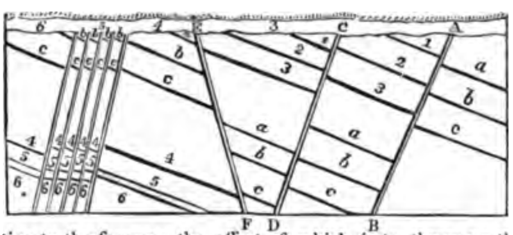


The effect of slips on the strata is also represented in the vertical section, *fig.* 813, where *a*, *b*, *c* are coals with their associated strata. A, B, is an intersecting slip, which throws all the coals of the first compartment much lower, as is observable in the second No. 2; and from the amount of the slip, it brings in other coal-seams, marked 1, 2, 3 not in the compartment No. 1. C, D, is a slip producing a similar result, but not of the same magnitude. E, F represents a slip across the strata, reverse in direction to the former; the effect of which is to throw up the coals, as shown in the area No. 4. Such a slip occasionally brings into play seams seated under those marked *a*, *b*, *c*, as seen at 4, 5, 6; and it may happen that the coal marked 4 lies in the prolongation of a well-known seam, as C, in the compartment No. 3, when the case becomes puzzling to the miner. In addition to the above varieties, a number of slips or hitches are often seen near one another, as in the area marked No. 5, where the individual displacements are inconsiderable, but the aggregate dislocation may be great, in reference to the seams of the 6th compartment.

813



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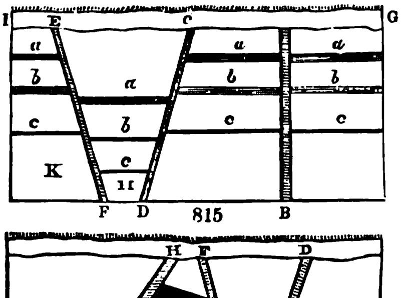
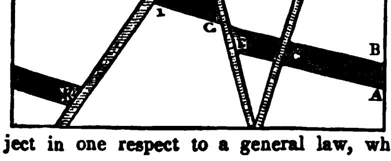


The results of dikes and slips on a horizontal portion of a field are exemplified in *fig.* 814. Where the coal-measures are horizontal, and the faults run at a greater angle than 45° to the line of bearing, they are termed dip and rise faults, as A B, C D, E F.

815



Coal-viewers or engineers regard the dislocations now described as being subject in one respect to a general law, which may be thus explained:—Let *fig.* 815

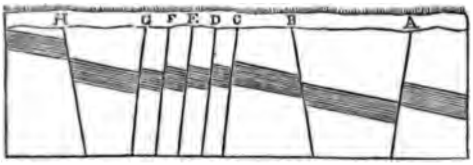
be a portion of a coal-measure; A, being the pavement and B the roof of the coal-seam. If, in pursuing the stratum at C, a dike D occurs, standing at right angles with the pavement, they conclude that the dike is merely a partition-wall between the beds by its own thickness, leaving the coal-seam underanged on either side; but if a dike F forms, as at E, an obtuse angle with the pavement, they conclude that the dike is not a simple partition between the strata, but has thrown up the several seams into the predicament shown at G. Finally, should a dike H make at I an acute angle with the pavement, they conclude that the dike has thrown down the coal-measures into the position of K.

The same important law holds with slips, as I formerly stated; only when they form right angles with the pavement, the case is ambiguous; that is, the strata may be dislocated either upwards or downwards.

Dikes and faults are denominated upthrow or downthrow, according to the position they are met with in working the mine. Thus, in *fig.* 812, if the miner in advancing to the rise, the dike A, B obviously does not change the direction; but C, D is a downthrow dike of a certain number of fathoms towards the rise of the basin, and E, F is an upthrow dike likewise towards the rise. On the other hand, when the dikes are met with by the miner in working from the rise to the dip, the names of the above dikes would be reversed; for what is an upthrow in the first case, becomes a downthrow in the second, relative to the mining operations.

3. We have seen that *hitches* are small and partial slips, where the dislocation does not exceed the thickness of the coal-seam; and they are correctly enough called *steps* by the miner. *Fig.* 816 represents the operation of the *hitches* A, B, C, D, E, F, G, H, on the coal-measures. Though observed in one or two seams of a field, they may not appear in the rest, as is the case with dikes and faults.

816



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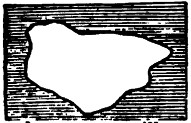

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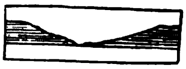

4. *Troubles* in coal-fields are of various kinds.

1. *Irregular layers of sandstone*, appearing in the middle of the coal-seam, and gradually increasing in thickness till they separate the coal into two distinct seams, too thin to continue workable.

2. *Nips*, occasioned by the gradual approximation of the roof and pavement, till not a vestige of coal is left between them; the softer shale disappearing also at the same time. *Figs.* 817 and 818 represent this accident, which is fortunately rare; the first being a vertical, and the second a horizontal view.

3. *Shaken coal.* It resembles the rubbish of an old waste, being a confused heap of coal-dust, mixed with small pieces of cubical coal, so soft that it can frequently be dug with the spade. This shattering is analogous to that observed occasionally in the flint nodules of the chalk formation; and seems like the effect of some electric tremor of the strata.

In searching for coal in any country, its concomitant rocks ought to be looked for, especially the carboniferous or mountain limestone, known by its organic fossils; (see Ure's Geology, p. 175, and corresponding plate of fossils;) likewise the outcrop of the millstone grit, and the newer red sandstone, among some rifts or façades of which, seams of coal may be discerned. But no assurance of coal can be had without boring or pitting.

Skill in boring judiciously for coal, distinguishes the genuine miner from the empirical adventurer, who, ignorant of the general structure of coal-basins, expends labor, time, and money at random, and usually to no purpose; missing the proper coal-field, and leading his employer to sink a shaft where no productive seams can be had. A skilful viewer, therefore, should always direct the boring operations, especially in an unexplored country.

The boring rods should be made of the best and most tenacious Swedish iron; in area, about an inch and a quarter square. Each rod is usually 3 feet long, terminating in a male screw at one end, and a female screw at the other. The boring chisels are commonly 18 inches long, and from 2 inches and a half to 3 inches and a quarter at their cutting edge, which must be tipped with good steel. The chisel is screwed to an intermediate 18-inch rod, called the double box-rod, forming together a rod 3 feet long. There are, moreover, three short rods, a foot, 18 inches, and 2 feet long each, which may be screwed, as occasion requires, to the brace-head, to make the height above the mouth of the bore convenient for the hands of the men in working the rods. Hence the series of rods becomes a scale of measurement for noting the depth of the bore, and keeping a journal of the strata that are perforated. The brace-head rod, also 18 inches long, has two large eyes or rings at its top, set at right angles to each other, through which arms of wood are fixed for the men to lift and turn the rods by, in the boring process.

When the bore is intended to penetrate but a few fathoms, the whole work may be performed directly by the hands; but when the bore is to be of considerable depth, a lofty triangle of wood is set above the bore hole, with a pulley depending at its summit angle, for conducting the rope to the barrel of a windlass or wheel and axle, secured to the ground with heavy stones. The loose end of the rope is connected to the rods by an oval iron ring, called a runner; and by this mechanism they may be raised and let fall in the boring; or the same effect may be more simply produced by substituting for the wheel and axle, a number of ropes attached to the rod rope, each of which may be pulled by a man, as in raising the ram of the pile engine.

In the Newcastle coal district there are professional master-borers, who undertake to search for coal, and furnish an accurate register of the strata perforated. The average price of boring in England or Scotland, where no uncommon difficulties occur, is six shillings for each of the first five fathoms, twice 6 shillings for each of the second five fathoms, thrice 6 shillings for each of the third five fathoms, and so on; hence the series will be—

1st five fathoms - - - - -	6s. each - - - - -	£1 10
2d five fathoms - - - - -	12s. — - - - - -	3 0
3d five fathoms - - - - -	18s. — - - - - -	4 10
4th five fathoms - - - - -	24s. — - - - - -	6 0
20 fathoms of bore - - - - -	- - - - - - - - -	£15 0

Thus the price increases equably with the depth and labor of the bore, and the undertaker usually upholds his rods. There are peculiar cases, however, in which the expense greatly exceeds the above rate.

The boring tools are represented in the following figures:—

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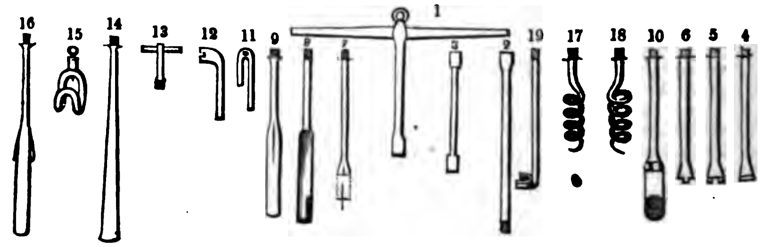


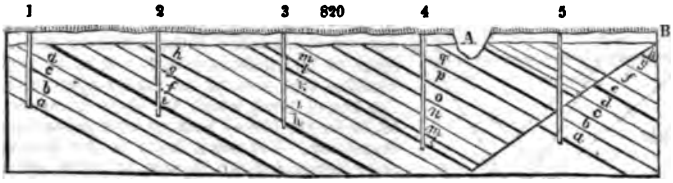
Fig. 819.

1. The *brace-head.*
2. The common rod.
3. The double-box rod; intermediate piece.
4. The common chisel.
5. The indented chisel.
6. Another of the same.
7. The cross-mouthed chisel.
8. The wimble.
9. The sludger, for bringing up the mud.
10. The rounder.
11. The key for supporting the train of rods at the bore-mouth.
12. The key for screwing together and asunder the rods.
13. The topit, or top-piece.
14. The beché, for catching the rod when it breaks in the bore.
15. The runner, for taking hold of the topit.
16. The tongued chisel.
17. The right-handed worm screw.
18. The left-handed do.
19. The finger grip or catch.

We shall now explain the manner of conducting a series of bores in searching ground for coal.

Fig. 820 represents a district of country in which a regular survey has proved the existence and general distribution of coal strata, with a dip to the south, as here shown. In this case, a convenient spot should be pitched upon in the north part ıe district, so that the successive bores put down may advance in the line of the

820



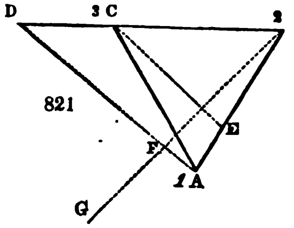
The first bore may therefore be made at No. 1, to the depth of sixty yards. In progress of this perforation, many diversities and alternations of strata will be ably passed through, as we see in the sections of the strata; each of which, as to ity and thickness, is noted in the journal, and specimens are preserved. This bore en to penetrate the strata *d*, *c*, *b*, *a*, without encountering any coal. Now, suppose the dip of the strata be one yard in ten, the question is, at what distance from bore 1, in a south direction, will a second bore of 60 yards strike the first stratum, *d*, of preceding? The rule obviously is, to multiply the depth of the bore by the dip, that 0 by 10, and the product, 600, gives the distance required; for, by the rule of three, yard of depression corresponds to 10 in horizontal length, 60 yards of depression correspond to 600 in length. Hence the bores marked 1, 2, 3, 4, and 5, are succesly distributed as in the figure, the spot where the first is let down being regarded as point of level to which the summits of all the succeeding bores are referred. Should top of No. 2 bore be 10 yards higher or lower than the top of No. 1, allowance must ıade for this difference in the operation; and hence a surface level survey is requisite. etimes ravines cut down the strata, and advantage should be taken of them, when are considerable.

ı No. 2, a coal is seen to occur near the surface, and another at the bottom of the ; the latter seam resting on the first stratum *d*, that occurred in bore No. 1; and 2 perforation must be continued a little farther, till it has certainly descended to the tum *d*. Thus these two bores have, together, proved the beds to the depth of 120 yards. o. 3 bore being placed according to the preceding rule, will pass through two coalns near the surface, and after reaching to nearly its depth of 60 yards, it will touch stratum *h*, which is the upper stratum of bore No. 2; but since a seam of coal was cted in No. 2, under the stratum *h*, the proof is confirmed by running the borer down ugh that coal. The field has now been probed to the depth of 180 yards. The th bore is next proceeded with, till the two coal-seams met in No. 3 have been pene- ed; when a depth of 240 yards has been explored. Hence No. 4 bore could not reach lower stratum *a*, unless it were sunk 240 yards.

he fifth bore (No. 5) being sunk in like manner, a new coal-seam occurs within a yards of the surface; but after sinking to the depth at which the coal at the top of fourth bore was found, an entirely different order of strata will occur. In this nmà, the bore should be pushed 10 or 20 yards deeper than the 60 yards, to ascertain alternations of the new range of superposition. It may happen that no coals of any ıe shall be found, as the figure indicates, in consequence of a slip or dislocation of the ta at B, which has thrown up all the coals registered in the former borings, to such an nt that the strata *b*, *a*, of the first bore present themselves immediately on perforating slip, instead of lying at the depth of 300 yards (5 × 60), as they would have done, no dislocation intervened. Some coal-fields, indeed, are so intersected with slips as ewilder the most experienced miner, which will particularly happen when a lower is thrown upon one side of a slip, directly opposite to an upper coal situated on the r side of it; so that if the two seams be of the same thickness, erroneous conclusions almost inevitable.

Then a line of bores is to be conducted from the dip of the strata towards their out- , they should be placed a few yards nearer each other than the rule prescribes, lest strata last passed through be overstepped, so that they may disappear from the regis- and a valuable coal-seam may thereby escape notice. In fact, each successive bore ıld be so set down, that the first of the strata perforated should be the last passed ugh in the preceding bore; as is exemplified by viewing the bores in the retrograde ction, Nos. 4, 3, and 2. But if the bore No. 2 had gone no deeper than *f*, and the No. 1 had been as represented, then the stratum *e*, with its immediately subjacent , would have been overstepped, since none of the bores would have touched it; and would have remained unnoticed in the journal, and unknown.

Then the line of dip, and consequently the line of bearing which is at right angles to re unknown, they are sought for by making three bores in the following position. et *fig.* 821 be a horizontal diagram, in which the place of a bore, No. 1, is shown, which reaches a coal-seam at the depth of 50 yards; bore No. 2 may be made at B, 300 yards from the former; and bore No. 3 at C, equidistant from Nos. 1 and 2, so that the bores are sunk at the three angles of an equilateral triangle. If the coal occur in No. 2 at the depth of 30 yards, and in No. 3 of 44 yards, it is manifest that none of the lines A B, B C, or C A, is in the line of level, which for short distances may be taken for the line of bearing, with coal-seams of moderate dip. But since No. 1 is the deepest of the three bores, and No. 3 next in depth, the line A C joining them must be nearer the line of level than either of the lines A B or B C. The question is, therefore, at what distance on the prolonged line B C is the point for sinking a bore which would reach the coal at the same depth as No. 1, namely, 50 yards. This problem is solved by the following rule of proportion: as 14 yards (the difference of depth between bores 2 and 3) is to 300 yards (the distance between them), so is 20 (the difference of depth betwixt 1 and 2) to a fourth proportion, or $x = 428$ yards, 1 foot, and 8 inches. Now, this distance, measured from No. 2, reaches to the point D on the prolonged line B C, under which point D the coal will be found at a depth of 50 yards, the same as under A. Hence the line A D is the true level line of the coal-field; and a line B F G, drawn at right angles to it, is the true dip-line of the plane which leads to the outcrop. In the present example the dip is 1 yard in 14½; or 1 in 14½, to adopt the judicious language of the miner; or the sine is 1 to a radius of 14½, measured along the line from B to F. By this theorem for finding the lines of dip and level, the most eligible spot in a coal-field for sinking a shaft may be ascertained.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Suppose the distance from B to G in the line of dip to be 455 yards; then, since every 14½ gives a yard of depression, 455 will give 30 yards, which added to 30 yards, the depth of the bore at B, will make 60 yards for the depth of the same coal-seam at G. Since any line drawn at right angles to the line of level A D is the line of dip, so any line drawn parallel to A D is a level line. Hence, if from C the line C E be drawn parallel to D A, the coal-seam at the points E and C will be found in the same horizontal plane, or 44 yards beneath the surface level, over these two points. The point E level with C may also be found by this proportion: as 20 yards (the difference in depth of the bores under B and A) is to 300 yards (the distance between them), so is 14 yards (the difference of depth under B and C) to 210 yards, or the distance from B to E.

As boring for coal is necessarily carried on in a line perpendicular to the horizon, and as coal-seams lie at every angle of inclination to it, the thickness of the seam as given obliquely by the borer, is always greater than the direct thickness of the coal; and hence the length of that line must be multiplied by the cosine of the angle of dip, in order to find the true power of the seam.

Of fitting or winning a coal-field.—In sinking a shaft for working coal, the great obstacle to be encountered is water, particularly in the first opening of a field, which proceeds from the surface of the adjacent country; for every coal-stratum, however deep it may lie in one part of the basin, always rises till it meets the alluvial cover, or crops out, unless it be met by a slip or dike. When the basset-edge of the strata is covered with gravel or sand, any body or stream of water will readily percolate downwards through it, and fill up the porous interstices between the coal-measures, till arrested by the face of a slip, which acts as a valve or flood-gate, and confines the water to one compartment of the basin, which may, however, be of considerable area, and require a great power of drainage.

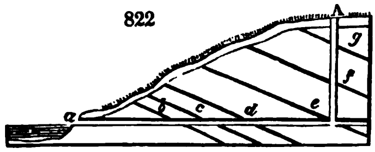
In reference to water, coal-fields are divided into two kinds: 1. level free coal; 2. coal not level free. In the practice of mining, if a coal-field, or portion of it, is so situated above the surface of the ocean that a level can be carried from that plane till it intersects the coal, all the coal above the plane of intersection is said to be level free; but if a coal-field, though placed above the surface of the ocean, cannot, on account of the expense, be drained by a level or gallery, but by mechanical power, such a coal-field is said to be not level free.

Besides these general levels of drainage, there are subsidiary levels, called off-takes or drifts, which discharge the water of a mine, not at the mouth of the pit, but at some depth beneath the surface, where, from the form of the country, it may be run off level free. From 20 to 30 fathoms off-take is an object of considerable economy in pumping; but even less is often had recourse to; and when judiciously contrived, may serve to intercept much of the crop water, and prevent it from getting down to the dip part of the coal, where it would become a heavy load on a hydraulic engine.

Day levels were an object of primary importance with the early miners, who had not the gigantic pumping power of the steam-engine at their command. Levels ought to be no less than 4 feet wide, and from 5 feet and a half to 6 feet high; which is large enough for carrying off water, and admitting workmen to make repairs and clear out depositions. When a day-level, however, is to serve the double purpose of drainage and an outlet for coals, it should be nearly 5 feet wide, and have its bottom gutter covered over. In other instances a level not only carries off the water from the colliery, but is converted into a canal for bearing boats loaded with coals for the market. Some subterranean canals are nine feet wide, and twelve feet high, with 5 feet depth of water.

If in the progress of driving a level, workable coals are intersected before reaching the seam which is the main object of the mining adventure, an air-pit may be sunk, of such dimension as to serve for raising the coals. These air-pits do not in general exceed 7 feet in diameter; and they ought to be always cylindrical. *Fig.* 822 represents a coal-field where the winning is made by a day-level; *a* is the mouth of the gallery on a level with the sea; *b*, *c*, *d*, *e* are intersected coal-seams, to be drained by the gallery. But the coals beneath this level must obviously be drained by pumping. A represents a coal-pit sunk on the coal *e*; and if the gallery be pushed forward, the coal-seams *f*, g, and any others which lie in that direction, will also be drained, and then worked by the pit A. The chief obstacle to the execution of day-levels, is presented by quicksands in the alluvial cover, near the entrance of the gallery. The best expedient to be adopted amid this difficulty is the following:—*Fig.* 823 represents the strata of a coal-field A, with the alluvial earth *a*, *b*, containing the bed of quicksand *b*. The lower part, from which the gallery is required to be carried, is shown by the line B *d*. But the quicksand makes it impossible to push forward this day-level directly. The pit B C must therefore be sunk through the quicksand by means of *tubbing* (to be presently described), and when the pit has descended a few yards into the rock, the gallery or drift may then be pushed forward to the point D, when the shaft E D is put down, after it has been ascertained by boring that the rock-head or bottom of the quicksand at F is a few yards higher than the mouth of the small pit B. During this operation, all the water and mine-stuff are drawn off by the pit B; but whenever the shaft E D is brought into communication with the gallery, the water is allowed to fill it from C to D, and rise up both shafts till it overflows at the orifice B. From the surface of the water in the deep shaft at G, a gallery is begun of the common dimensions, and pushed onwards till the coal sought after is intersected. In this way no drainage level is lost. This kind of drainage gallery, in the form of an inverted syphon, is called a drowned or a blind level.

822



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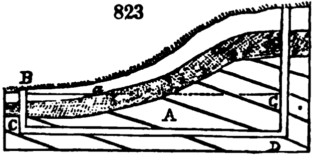


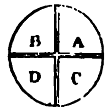
When a coal-basin is so situated that it cannot be rendered level free, the winning must be made by the aid of machinery. The engines at present employed in the drainage of coal-mines are:—

1. The water-wheel, and water-pressure engine.
2. The atmospheric steam-engine of Newcomen.
3. The steam-engine, both atmospheric and double stroke, of Watt.
4. The expansion steam-engine of Woolf.
5. The high-pressure steam-engine without a condenser.

The depth at which the coal is to be won, or to be drained of moisture, regulates the power of the engine to be applied, taking into account the probable quantity of water which may be found, a circumstance which governs the diameter of the working barrels of the pumps. Experience has proved, that in opening collieries, even in new fields, the water may generally be drawn off by pumps of from 10 to 15 inches diameter; excepting where the strata are connected with rivers, sand-beds filled with water, or marsh-lands. As feeders of water from rivers or sand-beds may be hindered from descending coal-pits, the growth proceeding from these sources need not be taken into account; and it is observed, in sinking shafts, that though the influx which cannot be cut off from the mine, may be at first very great, even beyond the power of the engine for a little while, yet as this excessive flow of water is frequently derived from the drainage of fissures, it eventually becomes manageable. An engine working the pumps for 8 or 10 hours out of the 24, is reckoned adequate to the winning of a new colliery, which reaps no advantage from neighboring hydraulic powers. In the course of years, however, many water-logged fissures come to be cut by the workings, and the coal-seams get excavated towards the outcrop, so that a constant increase of water ensues, and thus a colliery which has been long in operation, frequently becomes heavily loaded with water, and requires the action of its hydraulic machinery both night and day.

Of Engine Pits.—In every winning of coal, the shape of the engine-pit deserves much consideration. For shafts of moderate depth, many forms are in use; as circular, oval, square, octagonal, oblong rectangular, and oblong elliptical. In pits of inconsiderable depth, and where the earthy cover is firm and dry, any shape deemed most convenient may be preferred; but in all deep shafts, no shape but the circular shall be admitted. Indeed, when a water-run requires to be stopped by tubbing or cribbing, the circular is the only shape which presents a uniform resistance in every point to the equable circumambient pressure. The elliptical form is the next best, when it deviates little from the circle; but even it has almost always given way to a considerable pressure of water. The circular shape has the advantage, moreover, of strengthening the shaft walls, and is less likely to suffer injury than other figures, should any failure of the pillars left in working out the coal cause the shaft to be shaken by subsidence of the strata. The smallest engine-pit should be ten feet in diameter, to admit of the pumps being placed in the lesser segment, and the coals to be raised in the larger one, as shown in *fig.* 824, which is called a double pit. If much work is contemplated in drawing coals, particularly if their masses be large, it would be advantageous to make the pit more than 10 feet wide. When the area of a shaft is to be divided into three compartments, one for the engine pumps, and two for raising coals, as in *fig.* 825, which is denominated a triple pit, it should be 12 feet in diameter. If it is to be divided into four compartments, and made a quadrant shaft, as in *fig.* 826, with one space for the pumps, and three for ventilation and coal drawing, the total circle should be 15 feet in diameter. These dimensions are, however, governed by local circumstances, and by the proposed daily discharge of coals.

826



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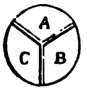
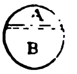


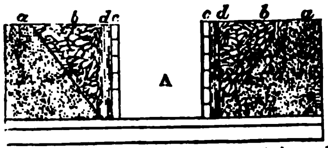
824



The shaft, as it passes through the earthy cover, should be securely faced with masonry of jointed ashler, having its joints accurately bevelled to the centre of the circle. Specific directions for building the successive masses of masonry, on a series of rings or cribs of oak or elm, are given by Mr. Bald, article Mine, *Brewster's Encyclopædia*, p. 336.

When the alluvial cover is a soft mud, recourse must be had to the operation of tubbing. A circular tub, of the requisite diameter, is made of planks from 2 to 3 inches thick, with the joints bevelled by the radius of the shaft, inside of which are cribs of hard wood, placed from 2 to 4 feet asunder, as circumstances may require. These cribs are constructed of the best heart of oak, sawn out of the natural curvature of the wood, adapted to the radius, in segments from 4 to 6 feet long, from 8 to 10 inches in the bed, and 5 or 6 inches thick. The length of the tub is from 9 to 12 feet, if the layer of mud have that thickness; but a succession of such tubs must be set on each other, provided the body of mud be thicker. The first tub must have its lower edge thinned all round, and shod with sharp iron. If the pit be previously secured to a certain depth, the tub is made to pass within the cradling, and is lowered down with tackles till it rests fair among the soft alluvium. It is then loaded with iron weights at top, to cause it to sink down progressively as the mud is removed from its interior. Should a single tub not reach the solid rock (sandstone or basalt), then another of like construction is set on, and the gravitating force is transferred to the top. *Fig.* 827 represents a bed of quicksand resting on a bed of impervious clay, that immediately covers the rock. A is the finished shaft; *a a*, the quicksand; *b b*, the excavation necessarily sloping much outwards; *c c*, the lining of masonry; *d d*, the moating or puddle of clay, hard rammed in behind the stone-work, to render the latter water-tight. In this case, the quicksand, being thin in body, has been kept under for a short period, by the hands of many men scooping it rapidly away as it filled in. But the most effectual method of passing through beds of quicksand, is by means of cast-iron cylinders; called, therefore, cast-iron tubbing. When the pit has a small diameter, these tubs are made about 4 feet high, with strong flanges, and bolt holes inside of the cylinder, and a counterfort ring at the neck of the flange, with brackets; the first tub, however, has no flange at its lower edge, but is rounded to facilitate its descent through the mud. Should the pit be of large diameter, then the cylinders must be cast in segments of 3, 4, or more pieces, joined together with inside vertical flanges, well jointed with oakum and white lead. When the sand-bed is thick, eighty feet, for instance, it is customary to divide that length into three sets of cylinders, each thirty feet long, and so sized as to slide within each other, like the eye tubes of a telescope. These cylinders are pressed down by heavy weights, taking care to

827



keep the lower part always further down than the top of the quicksand, where the men are at work with their shovels, and where the bottom of the pumps hangs for withdrawing the surface water. This is an improvement adopted of late years in the Newcastle district with remarkable success.

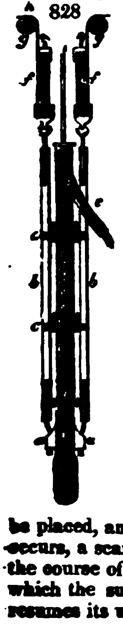
The engine pit being secured, the process of sinking through the rock is ready to be commenced, as soon as the divisions of the pit formed of carpentry, called brattices, are made. In common practice, and where great tightness of jointing is not required, for ventilating inflammable air, bars of wood, called buntons, about 6 inches thick, and 9 deep, are fixed in a horizontal position across the pit, at distances from each other of 10, 20, or 30 feet, according to circumstances. Being all ranged in the same vertical plane, deals an inch and a half thick are nailed to them, with their joints perfectly close; one half of the breadth of a bunton being covered by the ends of the deals. In deep pits, where the ventilation is to be conducted through the brattice, the side of the buntons next the pumps is covered with deals in the same way, and the joints are rendered secure by being calked with oakum. Fillets of wood are also fixed all the way down on each side of the brattice, constituting what is called a double pit.

When a shaft is to have 3 compartments, it requires more care to form the brattice, as none of the buntons stretch across the whole space, but merely meet near the middle, and join at certain angles with each other. As the buntons must therefore sustain each other, on the principle of the arch, they are not laid in a horizontal plane, but have a rise from the sides towards the place of junction of 8 or 9 inches, and are bound together by a three-tongued iron strap. Fillets of wood are carried down the whole depth, not merely at the joinings of the brattice with the sides of the pit, but also at their central place of union; while wooden pillars connect the centre of each set of buntons with those above and below. Thus the carpentry work acquires sufficient strength and stiffness.

In quadrant shafts the buntons cross each other towards the middle of the pit, and are generally let into each other about an inch, instead of being half-checked. *Fig.* 824 is a double shaft: A, the pump pit; B, the pit for raising coal. *Fig.* 825 is a triple shaft; in which A is the pump compartment; B and C are coal-pits. *Fig.* 826 is a quadrant shaft: A, the pump pit; B, pit of ventilation or upcast for the smoke; C and D, pits for raising coals.

A depth of 75 fathoms is fully the average of engine pits in Great Britain. In practice, it embraces three sets of pumps. Whenever the shaft is sunk so low that the engine is needed to remove the water, the first set of pumps may be let down by the method represented in *fig.* 828; where A is the pump; *a*, *a*, strong ears through which pass the iron rods connected with the spears *b b*; *c c* are the lashings; *d*, the hoggar pump; *e*, the hoggar; *f f*, the tackles; *g g*, the single pulleys; *h h*, the tackle fold leading to the capstans; and *i*, the pump-spears. By this mechanical arrangement the pumps are sunk in the most gradual manner, and of their own accord, so to speak, as the pit descends. To the arms of the capstans, sledges are fastened with ropes or chains; these sledges are loaded with weights, as counterpoises to the weight of the column of pumps, and when additional pumps are joined in, more weight is laid on the sledges. As the sinking set of pumps is constantly descending, and the point for the delivery of the water above always varying, a pipe of equal diameter with the pumps, and about 11 feet long, but much lighter in the metal, is attached to *e*, and is terminated by a hose of leather, of sufficient length to reach the cistern where the water is delivered. This is called the hoggar-pipe. In sinking, a vast quantity of air enters with the water, at every stroke of the engine; and therefore the lifting stroke should be very slow, and a momentary stop should take place before the returning stroke, to suffer all the air to escape. As the working barrels are generally 9 or 10 feet long, and the full stroke of the engine from 7 to 8 feet, when at regular work, it is customary to diminish the length of stroke, in sinking, to about 6 feet; because, while the pumps are constantly getting lower, the bucket in the working barrel has its working range progressively higher.

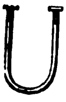
828



The usual length for a set of pumps, is from 25 to 30 fathoms. Whenever this depth is arrived at by the first set, preparations are made for fixing firmly the *upper* pit-cistern, into which the upper set of pumps is to be placed, and the water of the second set is to be thrown. If a strong bed of sandstone occurs, a scarcement of it is left projecting about 3 feet into the shaft, which is formed in the course of sinking into a strong chin or bracket, to sustain that part of the cistern in which the superior set of pumps stands. A few feet beneath this scarcement the shaft resumes its usual shape.

But although from 20 to 30 fathoms be the common length of a pump-lift, it sometimes becomes necessary to make it much longer, when no place can be found in the shaft for lodging a cistern, on account of the tubbing. Hence a pump-lift has been occasionally extended to 70 fathoms; which requires extraordinary strength of materials. The best plan for collaring the pumps in the pit, and keeping them steady in a perpendicular line, is to fix a strong bunton of timber under the joints of each pipe; and to attach the pipes firmly to these buntons by an iron collar, with screws and nuts, as represented in *fig.* 829.

829

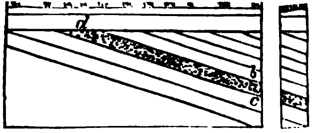


The water obtained in sinking through the successive strata is, in ordinary cases, conducted down the walls of the shaft; and if the strata are compact, a spiral groove is cut down the sides of the shaft, and when it can hold no more, the water is drawn off in a spout to the nearest pump-cistern; or a perpendicular groove is cut in the side of the shaft, and a square box-pipe either sunk in it, flush with the sides of the pit, or it is covered with deal boards well fitted over the cavity. Similar spiral rings are formed in succession downwards, which collect the trickling streams, and conduct them into the nearest cistern; or rings, made of wood or cast iron, are inserted flush with the sides of the pipe; and the water is led from one ring to another, through perpendicular pipes, until the undermost ring is full, when it delivers its water into the nearest pump-cistern. Keeping the shaft dry is very important to the comfort of the miners, and the durability of the work.

When an engine shaft happens to pass through a great many beds of coal, a gallery a few yards long is driven into each coal-seam, and a bore then put down from one coal to another, so that the water of each may pass down through these bores to the pump-cisterns.

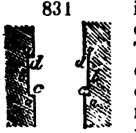
While a deep pit is sinking, a register is kept of every part of the excavations, and each feeder of water is measured daily, to ascertain its rate of discharge, and whether it increases or abates. The mode of measurement, is by noting the time, with a seconds watch, in which a cistern of 40 or 50 gallons gets filled. There are three modes of keeping back or stopping up these feeders, by plank tubbing; iron tubbing; and by oak cribs. Let *fig.* 830 represent the sinking of a shaft through a variety of strata, having a top cover of sand, with much water resting on the rock summit. Each plane of the coal-measure rises in a certain direction till it meets the alluvial cover. Hence, the pressure of the water at the bottom of the tubbing that rests on the summit of the rock, is as the depth of water in the superficial alluvium; and if a stratum *a* affords a great body of water, while the superjacent stratum *b*, and the subjacent *c*, are impervious to water; if the porous bed *a* be 12 feet thick, while no water occurs in the strata passed through from the rock head, until that depth (supposed to be 50 fathoms from the surface of the water in the cover); in this case, the tubbing or cribbing must sustain the sum of the two water pressures, or 62 fathoms; since the stratum *a* meets the alluvial cover at *d*, the fountain head of all the water that occurs in sinking. Thus we perceive, that though no water-feeder of any magnitude should present itself till the shaft had been sunk 100 fathoms; if this water required to be stopped up or tubbed off through the breadth of a stratum only 3 feet thick, the tubbing floodgate would need to have a strength to resist 100 fathoms of water-pressure. For though the water at first oozes merely in discontinuous particles through the open pores of the sands and sandstones, yet it soon fills them up, like a myriad of tubes, which transfer to the bottom the total weight of the hydrostatic column of 100 fathoms; and experience shows, as we have already stated, that whatever water occurs in coal-pits or in mines, generally speaking, proceeds from the surface of the ground. Hence, if the cover be an impervious bed of clay, very little water will be met with among the strata, in comparison of what would be found under sand.

830



When several fathoms of the strata must be tubbed, in order to stop up the water-flow, the shaft must be widened regularly to admit the kind of tubbing that is to be inserted; the greatest width being needed for plank-tubbing, and the least for iron-tubbing. *Fig.* 831 represents a shaft excavated for plank-tubbing, where *a*, *a*, *a* are the impervious strata, *b*, *b* the porous beds water logged, and *c*, *c* the bottom of the excavation, made level and perfectly smooth with mason-chisels. The same precautions are taken in working off the upper part of the excavation *d*, *d*. In this operation, three kinds of cribs are employed; called wedging, spiking, and main cribs. Besides the stout plank for making the tub, a quantity of well-seasoned and clean reeded deal is required for forming the joints; called sheeting deal by the workmen. This sheeting deal is always applied in pieces laid endwise, with the end of the fibres towards the area of the pit. Since much of the security from water depends on the

831



tightness of the tub at its jointing with the rock, several plans have been contrived to effect this object; the most approved being represented in *fig.* 832. To make room for the lower wedging crib, the recess is excavated a few inches wider, as at *c;* and from *b* to *c*, sheeting deals are laid all around the circle, or a thin stratum of oakum is introduced. On this the wedging crib *d* is applied, and neatly jointed in the radius-line of the pit, each segment being drawn exactly to the circle; and at each of its segments sheeting deal is inserted. This wedging crib must be 10 inches in the bed, and 6 inches deep. The vacuity *e*, at the back of the crib, about 2 and a half inches wide, is filled with pieces of dry clean reeded deal, inserted endwise; which is regularly wedged with one set of wedges all round, and then with a second and a third set of wedges, in the same regular style, to keep the crib in a truly circular posture. By this process, well executed, no water can pass downwards by the back of the crib. The next operation is to fix spiking cribs *f*, to the rock, about 10 or 12 feet from the lower crib, according to the length of the planks to be used for the tubs. They must be set fair to the sweep of the shaft, as on them its true circular figure depends. The tubbing deals *k*, must now be fixed. They are 3 inches thick, 6 broad, and planed on all sides, with the joints accurately worked to the proper bevel for the circle of the pit. The main cribs *g*, *g*, are then to be placed as counterforts, for the support and strength of the tubbing. The upper ends of the first set of tub-planks being cut square and level all round, the second spiking crib *l*, is fixed, and another set of tubbing deals put round like the former, having sheeting deal inserted betwixt the ends of the two sets at *f*. When this is wedged, the cribs *h*, *h*, are placed.

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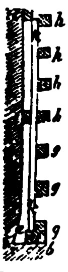

Oak cribbing is made with pieces of the best oak, from 3 to 4 feet long, 10 inches in the bed, and 7 or 8 inches deep.

The third mode of tubbing, by means of iron cylinders cast in segments, is likely henceforth to supersede the wooden tubbing, from the great reduction in the price of iron, and its superior strength and durability. Each segment is adjusted piece to piece in the circular recess of the pit cut out for their reception. The flange for the wedging joint is best turned inwards. In late improvements of this plan, executed by Mr. Buddle, where the pressure amounted to several hundred feet, the segments were 6 feet long, 2 feet broad, and an inch thick, counterforted with ribs or raised work on the back; the lip of the flange was strong, and supported by brackets. These segments of the iron cylinder are set true to the radius of the pit; and every horizontal and perpendicular joint is made tight with a layer of sheeting deal. A wedging crib is fixed at the bottom, and the segments are built up regularly with joints like ashlerwork. This kind of tubbing can be carried to any height, till the water finds an outlet at the surface, or till strata containing water can be tubbed off, as by the modes of tubbing already described. A shaft finished in this manner presents a smooth lining-wall of iron, the flanges being turned towards the outside of the cylinders. In this iron tubbing, no screw bolts are needed for joining the segments together; as they are packed hard within the pit, like the staves of a cask. There is a shaft in the Newcastle district, where 70 fathoms have been executed in this way, under the direction of Mr. Buddle.

When a porous thin bed or parting betwixt two impervious strata gives out much water, or when the fissures of the strata, called cutters, are very leaky, the water can be completely stopped up by the improved process of wedging. The fissure is cut open with chisels, to a width of two, and a depth of seven inches, as represented in *fig.* 833. The lips being rounded off about an inch and a half, pieces of clean deal are then driven in, whose face projects no further than the contour of the lips; when the whole is firmly wedged, till the water is entirely stopped. By sloping back the edges of the fissures, and wedging back from the face of the stone, it is not liable to burst or crack off in the operation, as took place in the old way, of driving in the wedge directly.

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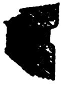
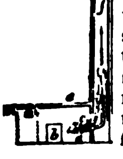


Ventilation of Engine pits.—In ordinary cases, while the sinking of the shaft is going on, the brattice walls produce a circulation, in consequence of the air being slightly lighter in one compartment than in another. If this does not occur, the circulation of air must be produced by artificial means. The most approved contrivance is, to cover the engine compartment of the shaft with deals, leaving apertures for the pump-spears and tackling to pass through, with hatch-doors for the men, and to carry a brick flue at leat 3 feet square, in a horizontal direction, from the mouth of that compartment to an adjoining high chimney connected with a furnace, as represented in *fig.* 834. *a*, *a*, are double doors, for the fireman to supply fuel by; *b*, the mouth of the horizontal flue; *c*, the furnace; *d*, the ash-pit; *e*, the furnace; *f*, the upright chimney for draught, from 50 to 100 feet high, from 8 to 10 feet square at bottom, and tapering upwards to 3 or 4 feet

834

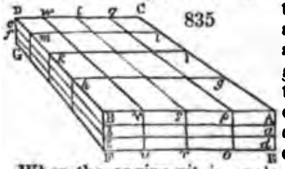


square inside. Such a furnace and chimney are also needed for ventilating the coal-mine through all its underground workings. When a great quantity of gas issues from one place in a pit, it is proper to carry it up in a square wooden pipe, which terminating at some distance above the surface in a helmet-shaped funnel, fitted to turn like a vane, may cause considerable ventilation of itself; or the top of such a pipe may be connected with a small fireplace, which will cause a rapid current up through it, from the pit. The stones and rubbish produced in sinking are drawn up with horse-gins, when the pit is not deep; but in all shafts of considerable depth, a steam engine is used, and the workmen have now more confidence in them, as to personal safety, than in machines impelled by horses.

The great collieries of Newcastle are frequently worked by means of one shaft divided into compartments, which serves as an engine-pit, and coal-pits, and by these the whole ventilation is carried on to an extent and through ramifications altogether astonishing. This system has been adopted on account of the vast expense of a large shaft, often amounting to 60,000*l.* or 80,000*l.*, including the machinery. The British collieries, however, are in general worked by means of an engine-pit, and a series of other pits, sunk at proper distances for the wants of the colliery.

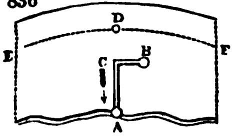
WORKING OF COAL.

A stratum, bed, or seam of coal, is not a solid mass, of uniform texture, nor always of homogeneous quality in burning. It is often divided and intersected, with its concomitant strata, by what are named partings, backs, cutters, reeds, or ends. Besides the chief partings at the roof and pavement of the coal seam, there are subordinate lines of parting in the coal mass, parallel to these, of variable dimensions. These divisions are delineated in *fig.* 835, where A, B, C, D, E F G D, represent a portion of a bed of coal, the parallelogram A B D C the parting at the roof, and E F G the parting at the pavement; *a b*, *b c*, *d e*, and *e f*, are the subordinate or intermediate partings; *g h*, *i k*, *l m*, the backs; *o p*, *p q*, *r s*, *s t*, *u v*, and *v w*, the cutters. It is thus manifest that a bed of coal, according to the number of these natural divisions, is subdivided into solid figures of various dimensions, and of a cubical or rhomboidal shape.



When the engine-pit is sunk, and the lodgment formed, a mine is then run in the coal to the rise of the field, or a cropping from the engine-pit to the second pit. This mine may be 6 or 8 feet wide, and carried either in a line directly to the pit bottom, or at right angles to the backs or web of the coal, until it is on a line with the pit, where a mine is set off, upon one side, to the pit bottom. This mine or gallery is carried as nearly parallel to the backs as possible, till the pit is gained. *Fig.* 836 represents this mining operation. A is the engine-pit. B, the second or by-pit. A C, the gallery driven at right angles to the backs. C B, the gallery set off to the left hand, parallel to the backs. The next step is to drive the drip-head or main-levels from the engine-pit bottom, or from the dip-hand of the backset immediately contiguous to the engine-pit bottom. In this business, the best colliers are always employed, as the object is to drive the gallery in a truly level direction, independently of all sinkings or risings of the pavement. For coal seams of ordinary thickness, this gallery is usually not more than 6 feet wide; observing to have on the dip side of the gallery a small quantity of water, like that of a gutter, so that it will always be about 4 or 6 inches deep at the forehead upon the dip-wall. When the level is driven correctly, with the proper depth of water, it is said to have dead water at the forehead. In this operation, therefore, the miner pays no regard to the backs or cutters of the coal; but is guided in his line of direction entirely by the water-level, which he must attend to solely, without regard to slips or dislocations of the strata throwing the coal up or down. In the last figure, the coal-field is a portion of a basin; so that if the shape be uniform and unbroken, and if any point be assumed a dipping from the crop, as D, the level lines from that point will be parallel to the line of crop, as D E, D F, and the levels from any point whatever a-dipping, will be also parallel to these; and hence, were the coal-field an entire elliptical basin, the dip-head levels carried from any point would be elliptical, and parallel to the crop. If, as is more commonly the case, the coal-field be merely a portion of a basin, formed by a slip of the strata, as represented in *fig.* 837, where *a*, *a*, *a*, is the crop, and A B, a slip of great magnitude, forming another coal-field on the side C, then the crop not only meets the alluvial cover, but is cut off by the slip at A and at B. Should any point, therefore, be assigned for an engine-pit, the levels from it will proceed in a line parallel to the crop, as D *d*, D C, and the level on both sides of

836



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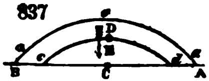

the engine-pit will be also cut off by the slip A B. In this figure, the part included between the two curve lines, is the breadth or breast of coal-field won by the engine-pit D; what is not included, is termed the under-dip coal, and can be worked only by one or more new winnings towards the dip, according to circumstances.

In British practice, there are four different systems of working coal-mines:—

1. Working with pillars and rooms, styled post and stall, where the pillars left bear such proportion to the coal excavated, as is just adequate to the support of the incumbent strata.

2. Working with post and stall, where the pillars are left of an extra size, and stronger than may be requisite for bearing the superior strata, with the intention of removing a considerable portion of each massive pillar, whenever the regular working of post and stall has been finished in the colliery.

3. Working with post and stall, or with comparatively narrow rooms or boards, whereby an uncommonly large proportion of coal is left, with the view of working back towards the pits, whenever the colliery is worked in this manner to the extent of the coal-field, and then taking away every pillar completely, if possible, and allowing the whole superincumbent strata to crush down, and follow the miners in their retreat.

4. Working the long way, being the Shropshire method; which leaves no pillars, but takes out all the coal progressively as the workings advance. On this plan, the incumbent strata crush down, creeping very close to the heads of the miners.

The post and stall system is practised with coals of every thickness. The Shropshire method is adopted generally with thin coals; for when the thickness exceeds 6 or 7 feet, this mode has been found impracticable.

The following considerations must be had in view in establishing a coal-mine:—

1. The lowest coal of the winning should be worked in such a manner as not to injure the working or the value of the upper coals of the field; but if this cannot be done, the upper coals should be worked in the first place.

2. The coals must be examined as to texture, hardness, softness, the number and openness of the backs and cutters.

3. The nature of the pavement of the coal seam, particularly as to hardness and softness; and if soft, to what depth it may be so.

4. The nature of the roof of the coal-seam, whether compact, firm, and strong; or weak and liable to fall; as also the nature of the superincumbent strata.

5. The nature of the alluvial cover of the ground, as to water, quicksands, &c.

6. The situation of rivers, lakes, or marshes, particularly if any be near the outcrop of the coal strata.

7. The situation of towns, villages, and mansion-houses, upon a coal-field, as to the chance of their being injured by any particular mode of mining the coal.

Mr. Bald gives the following general rules for determining the best mode of working coal:—

"1. If the coal, pavement, and roof are of ordinary hardness, the pillars and rooms may be proportioned to each other, corresponding to the depth of the superincumbent strata, providing all the coal proposed to be wrought is taken away by the first working, as in the first system; but if the pillars are to be winged afterwards, they must be left of an extra strength, as in the second system.

"2. If the pavement is soft, and the coal and roof strong, pillars of an extra size must be left, to prevent the pillars sinking into the pavement, and producing a creep.

"3. If the coal is very soft, or has numerous open backs and cutters, the pillars must be left of an extra size, otherwise the pressure of the superincumbent strata will make the pillars fly or break off at the backs and cutters, the result of which would be a total destruction of the pillars, termed a crush or sit, in which the roof sinks to the pavement, and closes up the work.

"4. If the roof is very bad, and of a soft texture, pillars of an extra size are required, and the rooms or boards comparatively very narrow.

"In short, keeping in view all the circumstances, it may be stated generally, that when the coal, pavement, and roof are good, any of the systems before mentioned may be pursued in the working; but if they are soft, the plan is to work with rooms of a moderate width, and with pillars of great extra strength, by which the greater part of the coal may be got out at the last of the work, when the miners retreat to the pit bottom, and there finish the workings of a pit."

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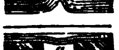

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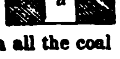
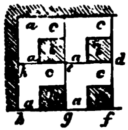


Fig. 838 represents the effects of pillars sinking into the pavement, and producing a creep; and *fig.* 839 exhibits large pillars and a room, with the roof stratum bending down before it falls at *a*. Thus the roads will be shut up, the air-courses destroyed, and the whole economy of the mining operations deranged.

The proportion of coal worked out, to that left in the pillars, when all the coal intended to be removed is taken out at the first working, varies from four fifths to two thirds; but as the loss of even one third of the whole area of coal is far too much, the better mode of working suggested in the third system ought to be adopted.

The proportion of a winning to be worked may be thus calculated. Let *fig.* 840 be a small portion of the pillars, rooms, and thirlings formed in a coal-field; *a*, *a*, are two rooms; *b*, the pillars; *c*, the thirlings (or area worked out). Suppose the rooms to be 12 feet wide, the thirlings to be the same, and the pillars 12 feet on each side; adding the face of the pillar to the width of the room, the sum is 24; and also the end of the pillar to the width of the thirling, the sum is likewise 24: then 24×24=576; and the area of the pillar is 12×12=144; and as 576 divided by 144 gives 4 for a quotient, the result is, that one fourth of the coal is left in pillars, and three fourths extracted. Let *d*, *e*, *f*, *g*, be one winning, and *g*, *e*, *k*, *h*, another. By inspecting the figure, we perceive the workings of a coal-field are resolved into quadrangular areas, having a pillar situated in one of the angles.

840



In forming the pillars and carrying forwards the boards with regularity, especially where the backs and cutters are very distinct and numerous, it is of importance to work the rooms at right angles to the backs, and the thirlings in the direction of the cutters, however oblique these may be to the backs, as the rooms are by this means conducted with the greatest regularity with regard to each other, kept equidistant, and the pillars are strongest under a given area. At the same time, however, it seldom happens that a back or cutter occurs exactly at the place where a pillar is formed; but this is of no consequence, as the shearing or cutting made by the miner ought to be in a line parallel to the backs and cutters. It frequently happens that the dip-head level intersects the cutters in its progress at a very oblique angle. In this case, when rooms and pillars are set off, the face of the pillar and width of the room must be measured off an extra breadth in proportion to the obliquity, as in *fig.* 841. By neglect of this rule, much confusion and irregular work are often produced. It is, moreover, proper to make the first set of pillars next the dip-head level much stronger, even where there is no obliquity, in order to protect that level from being injured by any accidental crush of the strata.

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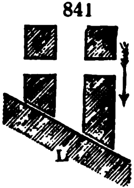

We shall now explain the different systems of working: one of the simplest of which is shown in *fig.* 842; where A represents the engine-pit, B the by-pit, C D the dip-head levels, always carried in advance of the rooms, and E the rise or crop gallery, also carried in advance. These galleries not only open out the work for the miners in the coal-bed, but, being in advance, afford sufficient time for any requisite operation, should the mines be obstructed by dikes or hitches. In the example before us, the rooms or boards are worked from the dip to the crop; the leading rooms, or those most in advance, are on each side of the crop gallery E; all the other rooms follow in succession, as shown in the figure; consequently, as the rooms advance to the crop, additional rooms are begun at the dip-head level, towards C and D. Should the coal work better in a level-course direction, then the level rooms are next the dip-head level, and the other rooms follow in succession. Hence the rooms are carried a cropping in the one case, till the coal is cropped out, or is no longer workable; and in the other, they are extended as far as the extremity of the dip-head level, which is finally cut off, either by a dike or slip, or by the boundary of the coal-field.

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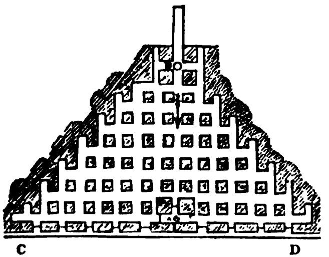
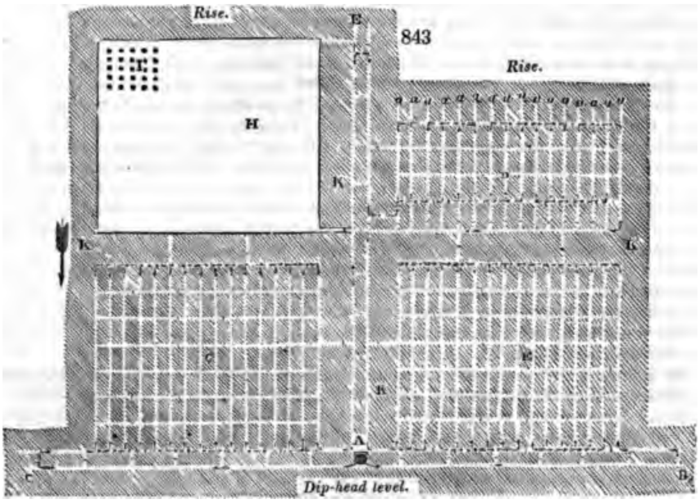


When the winnings are so very deep as from 100 to 200 fathoms, the first workings are carried forward with rooms, pillars, and thirlings, but under a different arrangement, on account of the great depth of the superincumbent strata, the enormous expense incident to sinking a pit, and the order and severity of discipline indispensable to the due ventilation of the mines, the preservation of the workmen, and the prosperity of the whole establishment. To the celebrated Mr. Buddle the British nation is under the greatest obligations for devising a new system of working coal-mines, whereby nearly one third of the coals has been rescued from waste and permanent destruction. This system is named panel work; because, instead of carrying on the coal-field winning in one extended area of rooms and pillars, it is divided into quadrangular panels, each panel containing an area of from 8 to 12 acres; and round each panel is left at first a solid wall of coal from 40 to 50 yards thick. Through the panel walls roads and air-courses are driven, in order to work the coal contained within these walls. Thus all the panels are connected together with the shaft, as to roads and ventilation. Each district or panel has a particular name; so that any circumstance relative to the details of the colliery, casualties as to falls and crushes, ventilation, and the safety of the workmen, can be referred to a specific place.

Fig. 843 represents a part of a colliery laid out in four panels, according to the improved method. To render it as distinct as possible, the line of the boards is at right angles with the dip-head level, or level course of the coal. A is the engine-shaft, divided into three compartments, an engine-pit and two coal-pits, like *fig.* 825. One of the coal-pits is the down-cast, by which the atmospheric air is drawn down to ventilate the works; the other coal-pit is the up-cast shaft, at whose bottom the furnace for rarefying the air is placed. B C, is the dip-head level; A E, the rise or crop gallery; K, K, the panel walls; F, G, are two panels completed as to the first work; D, is a panel, with the rooms *a*, *a*, *a*, in regular progress to the rise; H, is a panel fully worked out, whence nearly all the coal has been extracted; the loss amounting in general to no more than a tenth, instead of a third, or even a half, by the old method. By this plan of Mr. Buddle's, also, the pillars of a panel may be worked out at any time most suitable for the economy of the mining operation; whereas formerly, though the size of the pillars and general arrangement of the mine were made with the view of taking out ultimately a great proportion of the pillars, yet it frequently happened that, before the workings were pushed to the proposed extent, some part of the mine gave way, and produced a crush; but the most common misfortune was the pillars sinking into the pavement, and deranging the whole economy of the field. Indeed, the crush or creep often overran the whole of the pillars, and was resisted only by the entire body of coal at the wall faces; so that the ventilation was entirely destroyed, the roads leading from the wall faces to the pit-bottom shut up and rendered useless, and the recovery of the colliery by means of new air-courses, new roads, and by opening up the wall faces or rooms, was attended with prodigious expense and danger. Even when the pillars stood well, the old method was attended with other very great inconveniences. If water broke out in any particular spot of the colliery, it was quite impossible to arrest its progress to the engine-pit; and if the ventilation was thereby obstructed, no idea could be formed where the cause might be found, there being instances of no less than 30 miles of air-courses in one colliery. And if from obstructed ventilation an explosion of the fire-damp occurred while many workmen were occupied along the extended wall faces, it was not possible to determine where the disaster had taken place; nor could the viewers and managers know where to bring relief to the forlorn and mutilated survivers.


843

In Mr. Buddle's system all these evils are guarded against, as far as human science and foresight can go. He makes the pillars very large, and the rooms or boards narrow; the pillars being in general 12 yards broad, and 24 yards long; the boards 4 yards wide, and the walls or thirlings cut through the pillars from one board to another, only 5 feet wide, for the purpose of ventilation. In the figure, the rooms are represented as proceeding from the dip to the crop, and the panel walls act as barriers thrown round the area of the panel, to prevent the weight of the superincumbent strata from overrunning the adjoining panels. Again, when the *pillars* of a panel are to be worked, one range of pillars, as at I (in H), is first attacked; and as the workmen cut away the furthest pillars, columns of prop-wood are erected betwixt the pavement and the roof, within a few feet of each other (as shown by the dots), till an area of above 100 square yards is cleared of pillars, presenting a body of strata perhaps 130 fathoms thick, suspended clear and without support, except at the line of the surrounding pillars. This operation is termed working the *goaff*. The only use of the prop-wood is to prevent the seam, which forms the ceiling over the workmen's heads, from falling down and killing them by its splintery fragments. Experience has proved, that before proceeding to take away another set of pillars, it is necessary to allow the last-made goaff to fall. The workmen then begin to draw out the props, which is a most hazardous employment. They begin at the more remote props, and knock them down one after another, retreating quickly under the protection of the remaining props. Meanwhile the roof-stratum begins to break by the sides of the pillars, and falls down in immense pieces; while the workmen still persevere, boldly drawing and retreating till every prop is removed. Nay, should any props be so firmly fixed by the top pressure, that they will not give way to the blows of heavy mauls, they are cut through with axes; the workmen making a point of honor to leave not a single prop in the goaff. The miners next proceed to cut away the pillars nearest to the sides of the goaff, setting prop-wood, then drawing it, and retiring as before, until every panel is removed, excepting small portions of pillars which require to be left under dangerous stones to protect the retreat of the workmen. While this operation is going forward, and the goaff extending, the superincumbent strata being exposed without support over a large area, break progressively higher up; and when strong beds of sandstone are thus giving way, the noise of the rending rocks is very peculiar and terrific; at one time loud and sharp, at another hollow and deep.

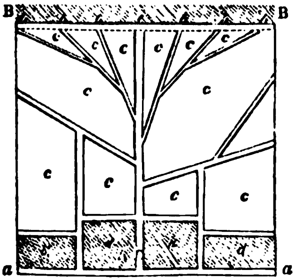
As the pillars of the panels are taken away, the panel walls are also worked progressively backwards to the pit bottom; so that only a very small proportion of coal is eventually lost. This method is undoubtedly the best for working such coals as those of Newcastle, considering their great depth beneath the surface, their comparative softness, and the profusion of inflammable air. It is evident that the larger the pillars and panel walls are, in the first working, the greater will be the security of the miners, and the greater the certainty of taking out, in the second stage, the largest proportion of coal. This system may be applied to many of the British collieries; and it will produce a vast quantity of coals beyond the post and stall methods, so generally persisted in.

In thus tearing to pieces the massive rocks over his head, the miner displays a determined and cool intrepidity; but his ingenuity is no less to be admired in contriving modes of carrying currents of pure atmospheric air through every turning of his gloomy labyrinth, so as to sweep away the explosive spirit of the mine.

The fourth system of working coal, is called the *long way*, the long-wall, and the Shropshire method. The plan must at first have been extremely hazardous; though now it is so improved as to be reckoned as safe, if not safer, to the workmen, than the other methods, with rooms and pillars.

The object of the Shropshire system, is to begin at the pit-bottom pillars, and to cut away at once every inch of coal progressively forward, and to allow the whole superincumbent strata to crush down behind and over the heads of the workmen. This plan is pursued chiefly with coals that are thin, and is very seldom adopted when the seam is 7 feet thick; from 4 to 5 feet being reckoned the most favorable thickness for proceeding with comfort, amidst ordinary circumstances, as to roof, pavement, &c. When a pit is opened on a coal to be treated by this method, the position of the coals above the lowest seam sunk to, must first be considered; if the coal beds be contiguous, it will be proper to work the upper one first, and the rest in succession downwards; but if they are 8 fathoms or more apart, with strata of strong texture betwixt them, the working of the lower coals in the first place will do no injury to that of the upper coals, except breaking them, perhaps, a little. In many instances, indeed, by this operation on a lower coal, upper coals are rendered more easily worked.

844

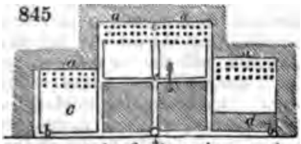


When the operation is commenced by working on the Shropshire plan, the dip-head levels are driven in the usual manner, and very large bottom pillars are formed, as represented in *fig.* 844. Along the rise side of the dip-head level, chains of wall, or long pillars, are also made, from 8 to 10 yards in breadth, and only mined through occasionally, for the sake of ventilation, or of forming new roads. In other cases no pillars are left upon the rise side of the level; but, instead of them, buildings of stone are reared, 4 feet broad at the base, and 9 or 10 feet from the dip side of the level. Though the roads are made 9 feet wide at first, they are reduced to half that width after the full pressure of the strata is upon them. Whenever these points are secured, the operation of cutting away the whole body of the coal begins. The place where the coal is removed, is named the *gobb* waste; and gobbin, or gobb-stuff, is stones or rubbish taken away from the coal, pavement, or roof, to fill up that excavation as much as possible, in order to prevent the crush of superincumbent strata from causing heavy falls, or following the workmen too fast in their descent. Coals mined in this manner work most easily according to the way in which the widest backs and cutters are; and therefore, in the Shropshire mode, the walls stand sometimes in one direction, and sometimes in another; the mine always turning out the best coals when the open backs and cutters face the workmen. As roads must be maintained through the crushed strata, the miners in the first place cut away about 15 feet of coal round the pit-bottom pillars, and along the upper sides of the dip-head chain walls; and then, at the distance of 9 or 10 feet, carry regular buildings of stone 3 feet broad, with props set flush with the faces of these, if necessary. As the miners advance, they erect small pillars of roof or pavement stone in regular lines with the wall face, and sometimes with props intermediate.

There are two principal modifications of the Shropshire plan. The first, or the original system, was to open out the wall round the pit-bottom; and, as the wall face extended, to set off main roads and branches, very like the branches of a tree. These roads were so distributed, that between the ends of any two branches there should be a distance of 30 or 40 yards, as might be most convenient. (See *fig.* 844.) Each space of coal betwixt the roads is called a wall; and one half of the coals produced from each wall is carried to the one road, and the other half to the other road. This is a great convenience when the roof is bad; and hence a distance of only 20 yards betwixt the roads is in many instances preferred. In *fig.* 844 A represents the shaft; B B, the wall-face; *a*, the dip-head level; *b*, the roads, from 20 to 40 yards asunder; *c*, the *gobb* or waste, with buildings along the sides of the roads; and *d*, the pillars.

The other Shropshire system is represented in *fig.* 845, where A shows the pit, with the bottom pillars; *b*, the dip-head levels; *c*, the off-break from the level, where no pillars are left; *d*, the off-break, where pillars remain to secure the level. All roads are protected in the sides by stone buildings, if they can be had, laid off 9 feet wide. After the crush settles, the roads generally remain permanently good, and can, in many cases, be travelled through as easily 50 years after they have been made, as at the first. Should stones not be forthcoming, coals must be substituted, which are built about 20 inches in the base. In this method, the roads are likewise from 20 to 40 yards apart; but instead of ramifying, they are arranged parallel to each other. The miners secure the waste by gobbing; and three rows of props are carried forwards next the wall faces *a*, with pillars of stone or of coal reared betwixt them. This mode has a more regular appearance than the other; though it is not so generally practised.

845



In the post and stall system, each man has his own room, and performs all the labor of it; but in that of Shropshire, there is a division of labor among the workmen, who are generally divided into three companies. The first set curves or pools the coal along the whole line of walls, laying in or pooling at least 3 feet, and frequently 45 inches, or 5 quarters, as it is called. These men are named *holers*. As the crush is constantly following them, and impending over their heads, causing frequent falls of coal, they plant props of wood for their protection at regular distances in an oblique direction between the pavement and wall face. Indeed, as a further precaution, staples of coal, about 10 inches square, are left at every 6 or 8 yards, till the line of holing or curving is completed. The walls are then marked off into spaces of from 6 to 8 yards in length; and at each space a shearing or vertical cut is made, as deep as the holing; and when this is done, the holer's work is finished. The set who succeed the holers, are called getters. These commence their operations at the centre of the wall divisions, and drive out the *gibbs* and staples. They next set wedges along the roof, and bring down progressively each division of coal; or, if the roof be hard-bound, the coal is blown down with gunpowder. When the roof has a good parting, the coals frequently fall down the moment the gibbs are struck; which makes the work very easy. The getters are relieved in their turn by the third set, named butty-men, who break down the coals into pieces of a proper size for sending up the shaft, and take charge of turning out the coal from the wall face to the ends of the roads. This being done, they build up the stone pillars, fill up the gobb, set the trees, clear the wall faces of all obstructions, set the gibbs, and make every thing clear and open for the holers to resume their work. If the roads are to be heightened by taking down the roof, or removing the pavement, these butty-men do this work also, building forwards the sides of the roads, and securing them with the requisite props. When a coal has a following or roof stone, which regularly separates with the coal, this facilitates the labor, and saves much of the coal;

and should a soft bed of fire-clay occur a foot or two beneath the coal-seam, the holing is made in it, instead of into the coal, and the stone betwixt the holing and the coal benched down, which serves for pillars and gobbing. In this way all the vendible coal becomes available.

Another form of the Shropshire system is, for each miner to have from 6 to 12 feet of coal before him, with a leading-hand man; and for the several workmen to follow in succession, like the steps of a stair. When the coal has open backs and cutters, this work goes on very regularly, as represented in *fig.* 846, where the leading miner is at *a* next to the outcrop, and *b b*, &c. are the wall faces of each workman; A being the shaft, and B the dip-head level. In this case the roads are carried either progressively through the gobb, or the gobb is entirely shut up; and the whole of the coals are brought down the wall-faces, either to the dip-head level or the road *c*, *c*. This method may be varied by making the walls broad enough to hold two, three, or four men when each set of miners performs the whole work of holing, getting, breaking down, and carrying off the coals.

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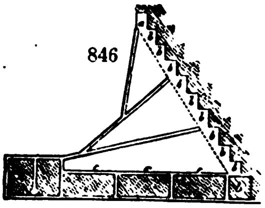

It is estimated that from one eighth to one twelfth part only of the coals remains under ground by the Shropshire plan; nay, in favorable circumstances, almost every inch of coal may be taken out, as its principle is to leave no solid pillars nor any coal below, except what may be indispensable for securing the gobb. Indeed, this system might be applied to coal-seams of almost any ordinary thickness, providing stuff to fill up the gobb could be conveniently procured.

In Great Britain, seams of coal are mined when they are only 18 inches thick; but if thinner, the working of fire-clay or ironstone immediately adjoining must be included. A few instances may be adduced, indeed, where caking coals of a fine quality for blacksmiths have been worked, though only in 12-inch seams.

Eighteen-inch seams are best worked by young lads and boys. The coal itself may be mined without lifting the pavement, or taking down the roof in the rooms; but roads must be cut either in the pavement or the roof, for removing the coals to the pit-bottom. All coals less than 2 feet 3 inches thick, are worked with the view of taking out all the coal, either on the Shropshire system, or with pillar-walls and rooms; with this peculiarity, that, on account of the thinness of the seam, the rooms are worked as wide as the roof will bear up; or if a following of the roof-stone, or fall of it, can be brought on, it proves advantageous, by not only giving head-room, but by filling up the waste, and rendering the roads easily kept for the working of the pillars. Where no following takes place, small temporary pillars, about 8 feet square, are left along the chain-wall side. The walls may vary in thickness from 4 to 16 yards, according to circumstances, and they are holed through only for ventilation.

Coals from 5 to 8 feet thick are the best suited in every point of view for the effective work of the miner, and for the general economy of underground operations. When they exceed that thickness, they require very excellent roofs and pavements, to render the working either safe or comfortable; or to enable those who superintend the field to get out a fair proportion of coal from a given area. In such powerful beds the Shropshire method is impracticable, from want of gobbin; and long props, unless of prodigious girth, would present an inadequate resistance to the pressure of the massive ceiling.

When coals do not exceed 20 feet in thickness, and have good roofs, they are sometimes worked as one bed of coal; but if the coal be tender or free, it is worked as two beds. One half of such thick coal, however, is in general lost in pillars; and it is very seldom that less than one third can be left. When the coal is free and ready to crumble by the incumbent pressure, as well as by the action of the air, the upper portion of the coal is first worked, then a scaffolding of coal is left, 2 or 3 feet thick, according to the compactness of the coal; and the lower part of the coal is now worked, as shown in *fig.* 817. As soon as the workings are completed to the proposed extent, the coal scaffoldings are worked away, and as much of the pillars as can be removed with safety. As propwood is of no use in coal-seams of such a height, and as falls from the roof would prove frequently fatal to the miners, it is customary with tender roofs to leave a ceiling of coal from 2 to 3 feet thick. This makes an excellent roof; and should it break, gives warning beforehand, by a peculiar crackling noise, very different from that of roof-stones crushing down.

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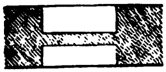
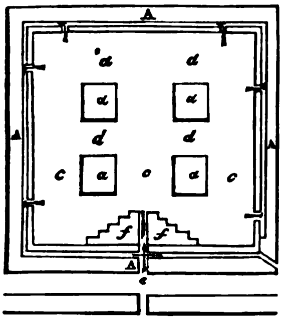


One of the thickest coals in Great Britain, worked as one bed from roof to pavement, is the very remarkable seam near the town of Dudley, known by the name of the ten-yard coal, about 7 miles long, and 4 broad. No similar coal has been found in the island; and the mode of working it is quite peculiar, being a species of panel work totally different from the modern Newcastle system. A compartment, or panel, formed in working the coal, is called a side of work and as the whole operation is exhibited in one of these compartments, it will be proper to describe the mode of taking the coal from one of them, before describing the whole extent of the workings of a mine.

848

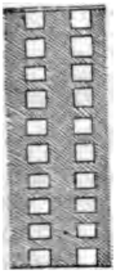


Let *fig.* 848 represent a side of work; A, the ribs or walls of coal left standing round, constituting the side of work; *a*, the pillars, 8 yards square; *c*, the stalls, 11 yards wide; *d*, the cross-openings, or through puts, also 11 yards wide; *e*, the bolt-hole, cut through the rib from the main road, by which bolt-hole the side of work is opened up, and all the coals removed. Two, three, or even four bolt-holes open into a side of work, according to its extent; they are about 8 feet wide, and 9 feet high. The working is in a great measure regulated by the natural fissures and joints of the coal-seam; and though it is 30 feet thick, the lower band, of 2 feet 3 inches, is worked first; the miners choosing to confine themselves within this narrow opening, in order to gain the greater advantage afterwards, in working the superjacent coal. Whenever the bolt hole is cut through, the work is opened up by driving a gallery forward, 4 feet wide, as shown by the dotted lines. At the sides of this gallery next the bolt-hole, each miner breaks off in succession a breast of coal, two yards broad, as at *f*, *f*, by means of which the sides of the rib-walls A are formed, and the area of the pillars. In this way each collier follows another, as in one of the systems of the Shropshire plan. When the side of work is laid open along the rib-walls, and the faces and sides of the pillars have been formed, the upper coals are then begun to be worked, next the rib-wall. This is done by shearing up to a bed next the bolt-hole, and on each side, whereby the head coals are brought regularly down in large cubical masses, of such thickness as suits with the free partings or subordinate divisions of the coals and bands. Props of wood, or even stone pillars, are placed at convenient distances for the security of the miners.

In working the ten-yard coal, a very large proportion of it is left under ground, not merely in pillars and rib-walls, but in the state of small coal produced in breaking out the coal. Hence, from four tenths to a half of the total amount is lost for ever.

Another method of working coal of uncommon thickness is by scaffoldings or stages of coals, as practised in the great coal bed at Johnstone, near Paisley, of which a section has already been given. In one part of the field the coal is from 50 to 60 feet thick, and in another it amounts to 90 feet. The seams of stone interspersed through the coal are generally inconsiderable, and amount in only two cases to 27 inches in thickness. The roof of the coal is so unsound, and the height so prodigious, that it could not possibly be worked in one seam, like that of Staffordshire. About 3 feet of the upper coal is therefore left as a roof, under which a band of coal, from 6 to 7 feet thick, is worked on the post and stall plan, with square pillars of extra strength, which are thereafter penetrated. A platform about 3 feet high is left at the sole; under which the rooms and pillars are set off and worked in another portion of the coal, from 5 to 7 feet thick, great care being had to place pillar under pillar, and partition under partition, to prevent a crush. Where the coal is thickest, no less than 10 bands of it are worked in this way, as is shown in *fig.* 849. When any band of the coal is foul from sulphur or other causes, it is left for the next platform, so that a large proportion of it is lost, as in the Staffordshire mines. Much attention must here be paid to the vertical distribution of the pillars and apartments; the miner's compass must be continually consulted, and bore-holes must be put down through the coal scaffoldings, to regulate correctly the position of the pillars under one another.

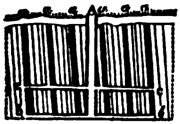
849



Edge coals, which are nearly perpendicular, are worked in a peculiar manner; for the collier stands upon the coal, having the roof on the one hand, and the floor on the other, like two vertical walls. The engine-pit is sunk in the most powerful stratum. In some instances the same stratum is so vertical as to be sunk through for the whole depth of the shaft.

Whenever the shaft has descended to the required depth, galleries are driven across the strata from its bottom, till the coals are intersected, as is shown in *fig.* 850, where we see the edge-coals at *a*, *a*; A, the engine-pit; *b*, *b*, the transverse galleries from the bottom of the shaft; and *c*, *c*, upper transverse galleries, for the greater conveniency of working the coal. The principal edge coal works in Great Britain lie in the neigh-

850



borhood of Edinburgh, and the coals are carried on the backs of women from the wall-face to the bottom of the engine-pit.

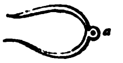
The modes of carrying coals from the point where they are excavated to the pit bottom are nearly as diversified as the systems of working.

One method employs hutches, or baskets, having slips or cradle feet shod with iron, containing from 2 to 3 hundred weight of coals. These baskets are dragged along the floor by ropes or leather harness attached to the shoulders of the workmen, who are either the colliers or persons hired on purpose. This method is used in several small collieries; but it is extremely injudicious, exercising the muscular action of a man in the most unprofitable manner. Instead of men, horses are sometimes yoked to these basket-hurdles, which are then made to contain from 4 to 6 hundred weight of coals; but from the magnitude of the friction, this plan cannot be commended.

An improvement on this system, where men draw the coals, is to place the basket or corve on a small four-wheeled carriage, called a tram, or to attach wheels to the corve itself. Thus much more work is performed, provided the floor be hard; but not on a soft pavement, unless some kind of wooden railway be laid.

The transport of coals from the wall-face to the bottom of the shaft was greatly facilitated by the introduction of cast-iron railways, in place of wooden roads, first brought into practice by Mr. John Curr of Sheffield. The rails are called tram-rails, or plate-rails, consisting of a plate from 3 to 4 inches broad, with an edge at right angles to it about two inches and a half high. Each rail is from 3 to 4 feet long, and is fixed either to cross bearers of iron, called sleepers, or more usually to wooden bearers. In some collieries, the miners, after working out the coals, drag them along these railways to the pit bottom; but in others, two persons called trammers are employed to transport the coals; the one of whom, in front of the corve, draws with harness; and the other, called the patter, pushes behind. The instant each corve arrives, from the wall-face, at a central spot in the system of the railways, it is lifted from the tram by a crane placed there, and placed on a carriage called a rolley, which generally holds two corves. Whenever three or four rolleys are loaded, they are hooked together, and the rolley driver, with his horse, takes them to the bottom of the engine-shaft. The rolley horses have a peculiar kind of shafts, commonly made of iron, named limbers, the purpose of which is to prevent the carriage from overrunning them. One of these shafts is represented in *fig.* 851. The hole shown at *a* passes over an iron peg or stud in front of the rolley, so that the horse may be quickly attached or disengaged. By these arrangements the work is carried on with surprising regularity and despatch.

851



The power of the engine for drawing the coals up the shaft is made proportional to the depth of the pit and the quantity to be raised, the corves ascending at an average velocity of about 12 feet per second. So admirable is the modern arrangement of this operation, that the corves are transported from the wall-faces to the pit bottom, and moved up the shaft, as fast as the onsetters at the bottom, and the banksmen at the top, can hook the loaded and empty corves on and off the engine ropes. Thus 100 corves of coals have been raised every hour up a shaft 100 fathoms deep, constituting a lift of 27 tons per hour, or 324 tons in a day, or shift of 12 hours. Coals mined in large cubical masses cannot, however, be so rapidly raised as the smaller coal of the Newcastle district.

When coals have so great a rise from the pit bottom to the crop that horses cannot be used on the rolley ways, the corves descend along the tram-roads, by means of inclined-plane machines, which are moved either by vertical rope-barrels, or horizontal rope-sheaves. These inclined planes are frequently divided into successive stages, 200 or 300 yards long, at the end of each of which is an inclined-plane machine, whereby the coals are lowered from one level to another.

The wheels of the trams and rolleys vary in diameter from 8 to 16 inches, according to the thickness of the coal. In some, the axles not only revolve on their journals, but the wheels also revolve on their axles.

Various forms of machines have been employed for raising the coals out of the pits. The steam engine with fly-wheel and rope-barrels is, however, now preferred in all considerable establishments. When of small power, they are usually constructed with a fly wheel, and short fly-wheel shaft, on which there is a small pinion working into the teeth of a large wheel, fixed upon the rope-barrel. Thus the engine may move with great rapidity, while it imparts an equable slow motion to the corves ascending in the shaft. When the engines are of great power, however, they are directly connected with the rope-barrel; some of these being of such dimensions, that each revolution of the rope-barrel produces an elevation of 12 yards in the corve. A powerful brake is usually connected with the circumference of the fly-wheel or rope-barrel, whereby the brakeman, by applying his foot to the governing lever of the brake, and by shutting at the same time the steam valves with his hands, can arrest the corve, or pitch its arrival within a few inches of the required height of every delivery. An endless chain, suspended from the bottom to the top of the shaft, has, in a few pits of moderate depth, been worked by a steam engine, for raising corves in constant succession; but the practice has not been found hitherto applicable on the greater scale.

There is a kind of water engines for raising coals, strictly admissible only in level free pits, where the ascent of the loaded corve is produced by the descent of a cassoon filled with water. When the ascent and descent are through equal spaces, the rope barrels for the cassoon and the corves are of equal diameter; but when the point from which the coals have to be lifted is deeper than the point of discharge for the water into the dry level, the cassoon must be larger, and the rope barrel smaller; so that by the time the cassoon reaches to the half-depth, for example, the corve may have mounted through double the space. The cassoon is filled with water at the pit mouth, and is emptied by a self-acting valve whenever it gets to the bottom. The loaded corve is replaced by an empty one at the pit mouth, and its weight, with that of the descending rope, pull up the empty cassoon; the motions of the whole mechanism being regulated by a powerful brake.

Various plans have been devised to prevent collision between the ascending and descending corves, which sometimes pass each other with a joint velocity of 20 or 30 feet per second. One method is by dividing the pit from top to bottom, so that each corve moves in a separate compartment. Another mode was invented by Mr. Curr of Sheffield, in which wooden guides were attached from top to bottom of the pit; being spars of deal about 4 inches square, attached perpendicularly to the sides of the shaft, and to buntons in the middle of the pit. Betwixt these guides, friction-roller sliders are placed, attached to the gin-ropes, to which sliders the corves are suspended. In this way, the corves can be raised with great rapidity; but there is a considerable loss of time in banking the corve at the pit mouth, where shutters or sliding boards must be used. This plan is highly beneficial where the coals are in large lumps.

Both ropes and chains are used for lifting coals. The round ropes are shroud-laid; but the preferable rope is the flat band, made of four ropes placed horizontally together, the ropes being laid alternately right and left. In this way, the ropes counteract one another in the twist, hanging like a riband down the shaft; and are stitched strongly together by a small cord. Such rope bands are not only very pliable for their strength, which protects the heart of the rope from breaking, but as they lap upon themselves, a simple sheave serves as a rope-barrel. They possess the additional advantge, that by so lapping, they enlarge the diameter of the axle in which they coil, and thus make a compensation mechanically against the increasing length of rope descending with its corve. Thus the counterpoise chains, used in deep pits to regulate the descent, have been superseded. See ROPE-SPINNING.

When chains are preferred to ropes, as in very deep pits, the short pudding-link chains are mostly used. See CABLE.

The corves, after being landed or banked at the pit mouth, are drawn to the bin or coal-hill, either upon slips by horses, or by trammers on a tram-road. But with small coals, like the Newcastle, the pit head is raised 8 or 9 feet above the common level of the ground, and the coal-heap slopes downwards from that height. As the bins increase, tram-roads are laid outwards upon them.

I shall now describe the *ventilation* of coal mines. Into their furthest recesses, an adequate supply of fresh air must be carried forwards, for the purposes of respiration, and the combustion of candles; as also for clearing off the carbonic acid and carbureted hydrogen gases, so destructive to the miners, who call these noxious airs, from their most obvious qualities, choke-damp and fire-damp.

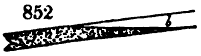
Before the steam engine was applied to the drainage of the mines, and the extraction of the coal, the excavations were of such limited extent, that when inflammable air accumulated in the foreheads, it was usual in many collieries to fire it every morning. This was done by fixing a lighted candle to the end of a long pole, which being extended towards the roof by a person lying flat on the floor, the gas was fired, and the blast passed safely over him. If the gas was abundant, the explosive miner put on a wet jacket, to prevent the fire from scorching him. In other situations, where the fire-damp was still more copious, the candle was drawn forwards into it, by a cord passing over a catch at the end of the gallery, while the operator stood at a distance. This very rude and dangerous mode of exploding the inflammable gas is still practised, in a few mines, under the name of the firing line.

The carbonic acid or choke-damp, having a greater specific gravity than atmospheric air, in the proportion of about 3 to 2, occupies the lower part of the workings, and gives comparatively little annoyance. Its presence may moreover be always safely ascertained by the lighted candle. This cannot, however, be said of the fire-damp, which being lighter and more moveable, diffuses readily through the atmospheric air, so as to form a most dangerous explosive mixture, even at a considerable distance from the blowers or sources of its extrication from the coal strata. Pure subcarbureted hydrogen has a specific gravity = 0·555, air being 1; and consists of a volume of vapor of carbon, and two volumes of hydrogen, condensed by mutual affinity into one volume. The choke-damp is a mixture of the above, with a little carbonic acid gas, and variable proportions of atmospheric air. As the pure subcarbureted hydrogen requires twice its bulk of oxygen to consume it completely, it will take for the same effect about 10 times its bulk of atmospheric air, since this volume of air contains about two volumes of oxygen. Ten volumes of air, therefore, mixed with one volume of subcarbureted hydrogen, form the most powerfully explosive mixture. If either less or more air be intermixed, the explosive force will be impaired; till 3 volumes of air below or above that ratio, constitute non-explosive mixtures; that is, 1 of the pure fire-damp mixed with either 7 or 13 of air, or any quantity below the first, or above the second number, will afford an unexplosive mixture. With the first proportion, a candle will not burn; with the second, it burns with a very elongated blue flame. The fire-damp should therefore be still further diluted with common air, considerably beyond the above proportion of 1 to 13, to render the working of the mine perfectly safe.

These noxious gases are disengaged from the cutters, fissures, and minute pores of the coal; and if the quantity be considerable, relative to the orifice, a hissing noise is heard.

Though the choke-damp, or carbonic acid gas, be invisible, yet its line of division from the common air is distinctly observable on approaching a lighted candle to the lower level, where it accumulates, which becomes extinguished the instant it comes within its sphere, as if it were plunged in water. The stratum of carbonic acid sometimes lies 1 or 2 feet thick on the floor, while the superincumbent air is perfectly good. When the coal has a considerable dip and rise, the choke-damp will be found occupying the lower parts of the mine, in a wedge form, as represented in *fig.* 852, where *a* shows the place of the carbonic acid gas, and *b* that of the common air.

852



When a gallery is driven in advance of the other workings, and a discharge of this gas takes place, it soon fills the whole mine, if its direction be in the line of level, and the mine is rendered unworkable until a supply of fresh air is introduced to dislodge it. As the flame of a candle indicates correctly the existence of the choke-damp, the miners may have sufficient warning of its presence, so as to avoid the place which it occupies, till adequate means be taken to drive it away.

The fire-damp is not an inmate of every mine, and is seldom found, indeed, where the carbonic acid prevails. It occurs in the greatest quantities in the coal mines of the counties of Northumberland, Durham, Cumberland, Staffordshire, and Shropshire. It is more abundant in coals of the caking kind, with a bright steel-grained fracture, than in cubic coals of an open-burning quality. Splint coals are still less liable to disengage this gas. In some extensive coal-fields it exists copiously on one range of the line of bearing, while on the other range none of it is observed, but abundance of carbonic acid gas.

In the numerous collieries in the Lothians, south from the city of Edinburgh, the fire-damp is unknown; while in the coal-fields round the city of Glasgow, and along the coast of Ayrshire, it frequently appears.

The violent discharge of the gas from a crevice or cutter of the coal, is called a blower; and if this be ignited, it burns like an immense blowpipe, inflaming the coal at the opposite side of the gallery. The gas evidently exists in a highly compressed and elastic state; whence it seems to loosen the texture of the coals replete with it, and renders them more easily worked. The gas is often peculiarly abundant near a great dislocation or slip of the strata; so that the fissure of the dislocation will sometimes emit a copious stream of gas for many years. It has also happened, that from certain coals, newly worked, and let fall from a height into the hold of a vessel, so much inflammable gas has been extricated that, after the hatches were secured, and the ship ready to proceed to sea, the gas has ignited with the flame of a candle, so as to scorch the seamen, to blow up the decks, and otherwise damage the vessel. In like manner, when the pillars in a mine are crushed by sudden pressure, a great discharge of gas ensues. This gas, being lighter than common air, always ascends to the roof or to the rise of the galleries; and, where the dip is considerable, occupies the forehead of the mine, in a wedge form, as shown in *fig.* 853, where *a* represents the fire-damp, and *b* the common air. In this case, a candle will burn without danger near the point c, close to the floor; but if it be advanced a few feet further towards the roof, an explosion will immediately ensue; since at the line where the two elastic fluids are in contact, they mix, and form an explosive body.

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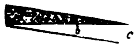

When this gas is largely diluted with air, the workmen do not seem to feel any inconvenience from breathing the mixture for a period of many years; but on inhaling pure carbureted hydrogen, the miner instantly drops down insensible, and, if not speedily removed into fresh air, he dies.

The production of these noxious gases renders ventilation a primary object in the system of mining. The most easily managed is the carbonic acid. If an air-pipe has been carried down the engine pit for the purpose of ventilation in the sinking, other pipes are connected with it, and laid along the pavement, or are attached to an angle of the mine next the roof. These pipes are prolonged with the galleries, by which means the air at the forehead is drawn up the pipes and replaced by atmospheric air, which descends by the shaft in an equable current, regulated by the draught of the furnace at the pit mouth. This circulation is continued till the miners cut through upon the second shaft, when the air-pipes become superfluous; for it is well known that the instant such communication is made, as is represented in *fig.* 854, the air spontaneously descends in the engine pit A, and, passing along the gallery *a*, ascends in a steady current in the second pit B. The air, in sinking through A, has at first the atmospheric temperature, which in winter may be at or under the freezing point of water; but its temperature increases in passing down through the relatively warmer earth, and ascends in the shaft B, warmer than the atmosphere. When shafts are of unequal depths, as represented in the figure, the current of air flows pretty uniformly in one direction. If the second shaft has the same depth with the first, and the bottom and mouth of both be in the same horizontal plane, the air would sometimes remain at rest, as water would do in an inverted syphon, and at other times would circulate down one pit and up another, not always in the same direction, but sometimes up the one, and sometimes up the other, according to the variations of temperature at the surface, and the barometrical pressures, as modified by winds. There is in mines a proper heat, proportional to their depth, increasing about one degree of Fahrenheit's scale for every 60 feet of descent.

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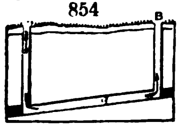

There is a simple mode of conducting air from the pit bottom to the forehead of the mine, by cutting a ragglin, or trumpeting, as it is termed, in the side of the gallery as represented in *fig.* 855, where A exhibits the gallery in the coal, and B the ragglin, which is from 15 to 18 inches square. The coal itself forms three sides of the air-pipe, and the fourth is composed of thin deals applied air-tight, and nailed to small props of wood fixed between the top and bottom of the lips of the ragglin. This mode is very generally adopted in running galleries of communication, and dip-head level galleries, where carbonic acid abounds, or when from the stagnation of the air the miners' lights burn dimly.

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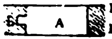

When the ragglin or air-pipes are not made spontaneously active, the air is sometimes impelled through them by means of ventilating fanners, having their tube placed at the pit bottom, while the vanes are driven with great velocity by a wheel and pinion worked with the hand. In other cases, large bellows like those of the blacksmith, furnished with a wide nozzle, are made to act in a similar way with the fanners. But these are merely temporary expedients for small mines. A very slight circulation of air can be effected by propulsion, in comparison of what may be done by exhaustion; and hence it is better to attach the air-pipe to the valve of the bellows, than to their nozzle.

Ventilation of collieries has been likewise effected on a small scale, by attaching a horizontal funnel to the top of air-pipes elevated a considerable height above the pit mouth. The funnel revolves on a pivot, and by its tail-piece places its mouth so as to receive the wind. At other times, a circulation of air is produced by placing coal-fires in iron grates, either at the bottom of an upcast pit, or suspended by a chain a few fathoms down.

Such are some of the more common methods practised in collieries of moderate depth, where carbonic acid abounds, or where there is a total stagnation of air. But in all great coal mines the aerial circulation is regulated and directed by double doors, called main or bearing doors. These are true air-valves, which intercept a current of air moving in one direction from mixing with another moving in a different direction. Such valves are placed on the main roads and passages of the galleries, and are essential to a just ventilation. Their functions are represented in the annexed *fig.* 856, where A shows the downcast shaft, in which the aerial current is made to descend; B is the upcast shaft, sunk towards the rise of the coal; and C, the dip-head level. Were the mine here figured to be worked without any attention to the circulation, the air would flow down the pit A, and proceed in a direct line up the rise mine to the shaft B, in which it would ascend. The consequence would therefore be, that all the galleries and boards to the dip of the pit A, and those lying on each side of the pits, would have no circulation of air; or, in the language of the collier, would be laid dead. To obviate this result, double doors are placed in three of the galleries adjoining the pit; viz., at *a* and *b*, *c* and *d*, *e* and *f*; all of which open inwards to the shaft A. By this plan, as the air is not suffered to pass directly from the shaft A to the shaft B, through

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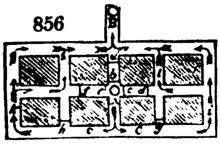

the doors *a* and *b*, it would have taken the next shortest direction by *c d* and *e f*; but the doors in these galleries prevent this course, and compel it to proceed downwards to the dip-head level c, where it will spread or divide, one portion pursuing a route to the right, another to the left. On arriving at the boards *g* and *h*, it would have naturally ascended by them; but this it cannot do, by reason of the building or stopping placed at *g* and *h*. By means of such stoppings placed in the boards next the dip-head level, the air can be transported to the right hand or to the left for many miles, if necessary, providing there be a train or circle of aerial communication from the pit A to the pit B. If the boards *i* and *k* are open, the air will ascend in them, as traced out by the arrows; and after being diffused through the workings, will again meet in a body at *a*, and mount the gallery to the pit B, sweeping away with it the deleterious air which it meets in its path. Without double doors on each main passage, the regular circulation of the air would be constantly liable to interruptions and derangements; thus, suppose the door *c* to be removed, and only *d* to remain in the left hand gallery, all the other doors being as represented, it is obvious, that whenever the door *d* is opened, the air, finding a more direct passage in that direction, would mount by the nearest channel *l*, to the shaft B, and lay dead all the other parts of the work, stopping all circulation. As the passages on which the doors are placed constitute the main roads by which the miners go to and from their work, and as the corves are also constantly wheeling along all the time, were a single door, such as *d*, so often opened, the ventilation would be rendered precarious or languid. But the double doors obviate this inconvenience; for both men and horses, with the corves, in going to or from the pit bottom A, no sooner enter the door *d*, than it shuts behind them, and encloses them in the still air contained between the doors *d* and *c*; *c* having prevented the air from changing its proper course while *d* was open. When *d* is again shut, the door *c* may be opened without inconvenience, to allow the men and horses to pass on to the pit bottom at A; the door *d* preventing any change in the aerial circulation while the door *c* is open. In returning from the pit, the same rule is observed, of shutting one of the double doors, before the other is opened.

If this mode of disjoining and insulating air-courses from each other be once fairly conceived, the continuance of the separation through a working of any extent, may be easily understood.

When carbonic acid gas abounds, or when the fire-damp is in very small quantity, the air may be conducted from the shaft to the dip-head level, and by placing stoppings of each room next the level, it may be carried to any distance along the dip-head levels; and the furthest room on each side being left open, the air is suffered to diffuse itself through the wastes, along the wall faces, and mount in the upcast pit, as is represented in *fig.* 842. But should the air become stagnant along the wall faces, stoppings are set up throughout the galleries, in such a way as to direct the main body of fresh air along the wall faces for the workmen, while a partial stream of air is allowed to pass through the stoppings, to prevent any accumulation of foul air in the wastes.

In very deep and extensive collieries more elaborate arrangements for ventilation are introduced. Here the circulation is made active by rarefying the air at the upcast shaft, by means of a very large furnace placed either at the bottom or top of the shaft. The former position is generally preferred. *Fig.* 834 exhibits a furnace placed at the top of the pit. When it surmounts a single pit, or a single division of the pit, the compartment intended for the upcast is made air-tight at top, by placing strong buntons or beams across it, at any suitable distance from the mouth. On these buntons a close scaffolding of plank is laid, which is well plastered or moated over with adhesive plastic clay. A little way below the scaffold, a passage is previously cut, either in a sloping direction, to connect the current of air with the furnace, or it is laid horizontally, and then communicates with the furnace by a vertical opening. If any obstacle prevent the scaffold from being erected within the pit, this can be made air-tight at top, and a brick flue carried thence along the surface to the furnace.

The furnace has a size proportional to the magnitude of the ventilation, and the chimneys are either round or square, being from 50 to 100 feet high, with an inside diameter of from 5 to 9 feet at bottom, tapering upwards to a diameter of from 2½ feet to 5 feet. Such stalks are made 9 inches thick in the body of the building, and a little thicker at bottom, where they are lined with fire-bricks.

The plan of placing the furnace at the bottom of the pit is, however, more advantageous, because the shaft through which the air ascends to the furnace at the pit mouth, is always at the ordinary temperature; so that whenever the top furnace is neglected, the circulation of air throughout the mine becomes languid, and dangerous to the workmen; whereas, when the furnace is situated at the bottom of the shaft, its sides get heated, like those of a chimney, through its total length, so that though the heat of the furnace be accidentally allowed to decline or become extinct for a little, the circulation will still go on, the air of the upcast pit being rarefied by the heat remaining in the sides of the shaft.

To prevent the annoyance to the onsetters at the bottom, from the hot smoke, the following plan has been adopted, as shown in the wood-cut, *fig.* 857, where *a* represents the lower part of the upcast shaft; *b*, the furnace, built of brick, arched at top, with its sides insulated from the solid mass of coal which surrounds it. Between the furnace wall and the coal beds, a current of air constantly passes towards the shaft, in order to prevent the coal catching fire. From the end of the furnace a gallery is cut in a rising direction at *c*, which communicates with the shaft at *d*, about 7 or 8 fathoms from the bottom of the pit. Thus the furnace and furnace-keeper are completely disjoined from the shaft; and the pit bottom is not only free from all encumbrances, but remains comfortably cool. To obviate the inconveniences from the smoke to the banksmen in landing the coals at the pit mouth, the following plan has been contrived for the Newcastle collieries. *Fig.* 858 represents the mouth of the pit; *a* is the upcast shaft, provided with a furnace at bottom; *b*, the downcast shaft, by which the supply of atmospheric air descends; and *d*, the brattice carried above the pit mouth. A little way below the settle-boards, a gallery *c* is pushed, in communication with the surface from the downcast shaft, over which a brick tube or chimney is built from 60 to 80 feet high, 7 or 8 feet diameter at bottom, and 4 or 5 feet diameter at top. On the top of this chimney a deal funnel is suspended horizontally on a pivot, like a turn-cap. The vane *f*, made also of deal, keeps the mouth of the funnel always in the same direction with the wind. The same mechanism is mounted at the upcast shaft *a*, only here the funnel is made to present its mouth in the wind's eye. It is obvious from the figure, that a high wind will rather aid than check the ventilation by this plan.

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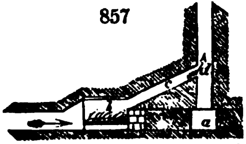

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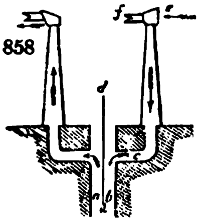

The principle of ventilation being thus established, the next object in opening up a colliery, and in driving all galleries whatever, is the *double mine* or double *headways course;* on the simple but very ingenious distribution of which, the circulation of air depends at the commencement of the excavations.

The double headways course is represented in *fig.* 859, where *a* is the one heading or gallery, and *b* the other; the former being immediately connected with the upcast side of the pit *c*, and the latter with the downcast side of the pit *d*. The pit itself is made completely air-tight by its division of deals from top to bottom, called the brattice wall; so that no air can pass through the brattice from *d* to *c*, and the intercourse betwixt the two currents of air is completely intercepted by a stopping betwixt the pit bottom and the end of the first pillar of coal; the pillars or walls of coal, marked *e*, are called stenting walls; and the openings betwixt them, walls or thirlings. The arrows show the direction of the air. The headings *a* and *b* are generally made about 9 feet wide, the stenting walls 6 or 8 yards thick, and are holed or thirled at such a distance as may be most suitable for the state of the air. The thirlings are 5 feet wide.

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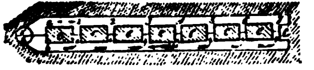

When the headings are set off from the pit bottom, an aperture is left in the brattice at the end of the pillar next the pit, through which the circulation betwixt the upcast and downcast pits is carried on; but whenever the workmen cut through the first thirling No. 1, the aperture in the brattice at the pit bottom is shut; in consequence of which the air is immediately drawn by the power of the upcast shaft through that thirling as represented by the dotted arrow. Thus a direct stream of fresh air is obviously brought close to the forehead where the mines are at work. The two headings *a* and *b* are then advanced, and as soon as the thirling No. 2 is cut through, a wall of brick and mortar, 4½ inches thick, is built across the thirling No. 1. This wall is termed a stopping; and being air-tight, it forces the whole circulation through the thirling No. 2. In this manner the air is always led forward, and caused to circulate always by the last-made thirling next the forehead; care being had, that whenever a new thirling is made, the last thirling through which the air was circulated, be secured with an air-tight stopping. In the woodcut, the stoppings are placed in the thirlings numbered 1, 2, 3, 4, 5, 6, and of consequence the whole circulation passes through the thirling No. 7, which lies nearest the foreheads of the headings *a*, *b*. By inspecting the figure, we observe, that on this very simple plan, a stream of air may be circulated to any required distance, and in any direction, however tortuous. Thus, for example, if while the double headways course *a*, *b*, is pushed forward, other double headways courses are required to be carried on at the same time on both sides of the first headway, the same general principles have only to be attended to as shown in *fig.* 860, where

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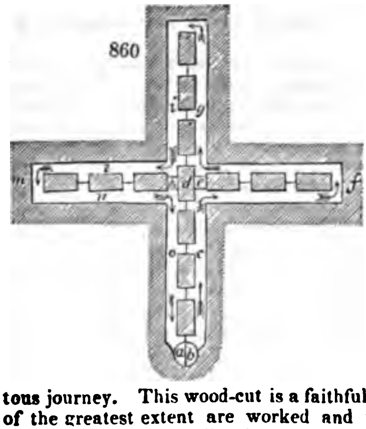

a is the upcast, and *b* the downcast shaft. The air advances along the heading *c*, but cannot proceed further in that direction than the pillar *d*, being obstructed by the double doors at *e*. It therefore advances in the direction of the arrows to the foreheads at *f*, and passing through the last thirling made there, returns to the opposite side of the double doors, ascends now the heading *g*, to the foreheads at *h*, passes through the last-made thirling at that point, and descends, in the heading *i*, till it is interrupted by the double doors at *k*. The aerial current now moves along the heading *l*, to the foreheads at *m*, returns by the last-made thirling there, along the heading *n*, and finally goes down the heading *o*, and mounts by the upcast shaft *a*, carrying with it all the noxious gases which it encountered during its circuitous journey. This wood-cut is a faithful representation of the system by which collieries of the greatest extent are worked and ventilated. In some of these, the air courses are from 30 to 40 miles long. Thus the air conducted by the medium of a shaft divided by a brattice wall only a few inches thick, after descending in the downcast in one compartment of the pit at 6 o'clock in the morning, must thence travel through a circuit of nearly 30 miles, and cannot arrive at its reascending compartment on the other side of the brattice, or pit partition, till 6 o'clock in the evening, supposing it to move all the time at the rate of 2½ miles per hour. Hence we see that the *primum mobile* of this mighty circulation, the furnace, must be carefully looked after, since its irregularities may affect the comfort, or even the existence of hundreds of miners spread over these vast subterraneous labyrinths. On the principles just laid down, it appears that if any number of boards be set off from any side of these galleries, either in a level, dip, or rise direction, the circulation of air may be advanced to each forehead, by an ingoing and returning current.

Yet while the circulation of fresh air is thus advanced to the last-made thirling next the foreheads *f*, *h*, and *m*, *fig.* 860, and moves through the thirling which is nearest to the face of every board and room, the emission of fire-damp is frequently so abundant from the coaly strata, that the miners dare not proceed forwards more than a few feet from that aerial circulation, without hazard of being burned by the combustion of the gas at their candles. To guard against this accident, temporary shifting brattices are employed. These are formed of deal, about ¾ of an inch thick, 3 or 4 feet broad, and 10 feet long; and are furnished with cross-bars for binding the deals together, and a few finger loops cut through them, for lifting them more expeditiously, in order to place them in a proper position. Where inflammable air abounds, a store of such brattice deals should be kept ready for emergencies.

The mode of applying these temporary brattices, or deal partitions, is shown in the accompanying figure (*fig.* 861), which shows how the air circulates freely through the thirling *d*, *d*, before the brattices are placed. At *b* and *c*, we see two heading boards or rooms, which are so full of inflammable air as to be unworkable. Props are now erected near the upper end of the pillar *e*, betwixt the roof and pavement, about two feet clear of the sides of the next pillar, leaving room for the miner to pass along between the pillar side and the brattice. The brattices are then fastened with nails to the props, the lower edge of the under brattice resting on the pavement, while the upper edge of the upper is in contact with the roof. By this means any variation of the height in the bed of coal is compensated by the overlap of the brattice boards; and as these are advanced, shifting brattices are laid close to, and alongside of, the first set. The miner next sets up additional props in the same parallel line with the former, and slides the brattices forwards, to make the air circulate close to the forehead where he is working; and he regulates the distance betwixt the brattice and the forehead by the disengagement of fire-damp and the velocity of the aerial circulation. The props are shown at *d*, *d*, and the brattices at *f*, *f*. By this arrangement the air is prevented from passing directly through the thirling *a*, and is forced along the right-hand side of the brattice, and, sweeping over the wall face or forehead, returns by the back of the brattice, and passes through the thirling *a*. It is prevented, however, from returning in its former direction by the brattice planted in the forehead *c*, whereby it mounts up and accomplishes its return close to that forehead. Thus headways and boards are ventilated till another thirling is made at the upper part of the pillar. The thirling *a* is then closed by a brick stopping, and the brattice boards removed forwards for a similar operation.

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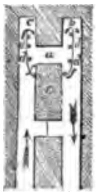

When blowers occur in the roof, and force the strata down, so as to produce a large vaulted excavation, the accumulated gas must be swept away; because, after filling that space, it would descend in an unmixed state under the common roof of the coal. The manner of removing it is represented in *fig.* 862, where *a* is the bed of coal, *b* the blower, *c* the excavation left by the downfall of the roof, *d* is a passing door, and *e* a brattice. By this arrangement the aerial current is carried close to the roof, and constantly sweeps off or dilutes the inflammable gas of the blower, as fast as it issues. The arrows show the direction of the current; but for which, the accumulating gas would be mixed in explosive proportions with the atmospheric air, and destroy the miners.

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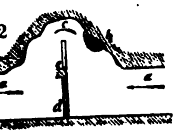

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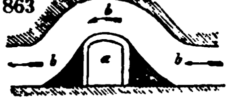

There is another modification of the ventilating system, where the air-courses are traversed across; that is, when one air-course is advanced at right angles to another, and must pass it in order to ventilate the workings on the further side. This is accomplished on the plan shown in *fig.* 863, where *a* is a main road with an air-course, over which the other air-course *b*, has to pass. The sides of this air channel are built of bricks arched over so as to be air-tight, and a gallery is driven in the roof strata as shown in the figure. If an air-course, as *a*, be laid over with planks made air-tight, crossing and recrossing may be effected with facility. The general velocity of the air in these ventilating channels is from 3 to 4 feet per second, or about 2½ miles per hour, and their internal dimensions vary from 5 to 6 feet square, affording an area of from 25 to 36 square feet.

Mr. Taylor's hydraulic air-pump, formerly described, p. 845, deserves to be noticed among the various ingenious contrivances for ventilating mines, particularly when they are of moderate extent. *a* is a large wooden tub, nearly filled with water, through whose bottom the ventilating pipe *b* passes down into the recesses of the mine. Upon the top of *b*, there is a valve *e*, opening upwards. Over *b*, the gasometer vessel is inverted in *a*, having a valve also opening outwards at *d*. When this vessel is depressed by any moving force, the air contained within it is expelled through *d*; and when it is raised, it diminishes the atmospherical pressure in the pipe *b*, and thus draws air out of the mine into the gasometer; which cannot return on account of the valve at *e*, but is thrown out into the atmosphere through *d* at the next descent.

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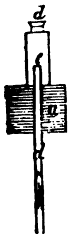
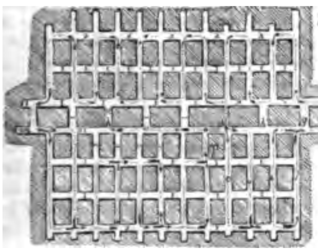


The general plan of distributing the air, in all cases, is to send the first of the current that descends in the downcast shaft among the horses in the stables, next among the workmen in the foreheads, after which the air, loaded with whatever mixtures it may have received, is made to traverse the old wastes. It then passes through the furnace with all the inflammable gas it has collected, ascends the upcast shaft, and is dispersed into the atmosphere. This system, styled *coursing the air*, was invented by Mr. Spedding of Cumberland. According to the quantity of the fire-damp, the coursing is conducted either up one room, and returned by the next alternately, through the whole extent of the works, or it passes along 2 or 3 connected rooms, and returns by the same number.

This admirable system has received the greatest improvements from the mining engineers of the Newcastle district, and especially from Mr. Buddle of Wallsend. His plan being a most complete scale of ventilation, where the aerial current is made to sweep away every corner of the workings, is shown in *fig.* 865; in which *a* represents the downcast, and *b* the upcast shaft. By pursuing the track of the arrows, we may observe that the air passes first along the two rooms *c*, *d*, having free access to each through the walls, but is hindered from entering into the adjoining rooms by the stoppings which form the air-courses. It sweeps along the wall faces of the rooms *c*, *d*, and makes a return down the rooms *e*, *f*, but is not allowed to proceed further in that direction by the stoppings *g*, *h*. It then proceeds to the foreheads *i*, *k*, and single courses all the rooms to the foreheads *l*, *m*; from this point it would go directly to the upcast pit *b*, were it not prevented by the stopping *n*, which throws it again into double coursing the rooms, till it arrives at *o*, whence it goes directly to the furnace, and ascends the shaft *b*. The lines across each other represent the passing doors; and these may be substituted in any place for a passage where there is a stopping. The stopping *p*, near the bottom of the downcast shaft, is termed a main stopping; because if it were removed, the whole circulation would instantly cease, and the air, instead of



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traversing in the direction of the arrows, would go directly from the downcast pit *a*, to the upcast pit *b*, along the gallery *q*. Hence every gallery and room of the workings would be laid *dead*, as it is termed, and be immediately filled with fire-damp, which might take fire either at the workmen's candles, or at the furnace next the upcast shaft *b*. Thus also a partial stagnation in one district of the colliery, would be produced by any of the common stoppings being accidentally removed or destroyed, since the air would thereby always pursue the nearest route to the upcast pit. Main stoppings are made particularly secure, by strong additional stone buildings, and they are set up at different places, to maintain the main air courses entire in the event of an explosion; by which precautions great security is given to human life. This system of ventilation may be extended to almost any distance from the pit-bottom, provided the volume of fresh air introduced be adequate to dilute sufficiently the fire-damp, so that the mixture shall not reach the explosive point. The air, by this management, ventilates first one panel of work, and then other panels in succession, passing onwards through the barriers or panel walls, by means of galleries, as in *fig.* 843, by the principle either of single, double, or triple coursing, according to the quantity of gas in the mine.

In ventilating the very thick coal of Staffordshire, though there is much inflammable air, less care is needed than in the north of England collieries, as the workings are very roomy, and the air courses of comparatively small extent. The air is conducted down one shaft, carried along the main roads, and distributed into the sides of work, as shown in *fig.* 848. A narrow gallery, termed the air-head, is carried in the upper part of the coal, in the rib walls, along one or more of the sides. In the example here figured, it is carried all round, and the air enters at the bolt-hole *e*. Lateral openings, named spouts, are led from the air-head gallery into the side of work; and the circulating stream mixed with the gas in the workings, enters by these spouts, as represented by the arrows, and returns by the air-head at *g*, to the upcast pit.

When the fire-damp comes off suddenly in any case, rendering the air foul and explosive at the foreheads, if no other remedy be found effectual, the working of the coal must be suspended, and a current of air sent directly from the fresh in-going stream, in order to dilute the explosive mixture, before it reaches the furnace. This is termed *skailing the air;* for otherwise the gas would kindle at the furnace, and flame backwards, like a train of gunpowder, through all the windings of the work, carrying devastation and death in its track. By *skailing* the air, however, time is given for running forward with water, and drowning the furnace. A cascade of water from the steam engine pumps is then allowed to fall down the pit, the power of which, through a fall of 500 or 600 feet, is so great in carrying down a body of air, that it impels a sufficient current through every part of the workings. The ventilation is afterwards put into its usual train at leisure.

In collieries which have been worked for a considerable time, and particularly in such as have goaves, creeps, or crushed wastes, the disengagement of the fire-damp from these recesses is much influenced by the state of atmospheric pressure. Should this be suddenly diminished, as shown by the fall of the barometer, the fire-damp suddenly expands and comes forth from its retirement, polluting the galleries of the mine with its noxious presence. But an increase of barometric pressure condenses the gases of the mine, and restrains them within their sequestered limits. It is therefore requisite that the coal-viewer should consult the barometer before inspecting the subterraneous workings of an old mine, on the Monday mornings, in order to know what precautions must be observed in his personal survey.

The catastrophe of an explosion in an extensive coal-mine is horrible in the extreme. Let us imagine a mine upwards of 100 fathoms deep, with the workings extended to a great distance under the surrounding country, with machinery complete in all its parts, the mining operations under regular discipline, and railways conducted through all its ramifications; the stoppings, passing doors, brattices, and the entire economy of the mine, so arranged that every thing moves like a well-regulated machine. A mine of this magnitude at full work is a scene of cheering animation, and happy industry; the sound of the hammer resounds in every quarter, and the numerous carriages, loaded or empty, passing swiftly to and fro from the wall faces to the pit bottom, enliven the gloomiest recesses. At each door a little boy, called a trapper, is stationed, to open and shut it. Every person is at his post, displaying an alacrity and happiness pleasingly contrasted with the surrounding gloom. While things are in this merry train, it has but too frequently happened that from some unforeseen cause, the ventilation has partially stagnated, allowing a quantity of the fire-damp to accumulate in one space to the explosive pitch; or a blower has suddenly sprung forth, and the unsuspecting miner, entering this fatal region with his candle, sets the whole in a blaze of burning air, which immediately suffocates and scorches to death every living creature within its sphere, while multitudes beyond the reach of the flame are dashed to pieces by the force of the explosion, rolling like thunder along the winding galleries. Sometimes the explosive flame seems to linger in one district for a few moments; then gathering strength for a giant effort, it rushes forth from its cell with the violence of a hurricane, and the speed of lightning, destroying every obstacle in its way to the upcast shaft. Its power seems to be irresistible. The stoppings are burst through, the doors are shivered into a thousand pieces; while the unfortunate miners, men, women, and boys, are swept along with an inconceivable velocity, in one body, with the horses, carriages, corves, and coals. Should a massive pillar obstruct the direct course of the aerial torrent, all these objects are dashed against it, and there prostrated or heaped up in a mass of common ruin, mutilation, and death. Others are carried directly to the shaft, and are either buried there amid the wreck, or are blown up and ejected from the pit mouth. Even at this distance from the explosive den, the blast is often so powerful, that it frequently tears the brattice walls of the shaft to pieces, and blows the corves suspended in the shaft as high up into the open air as the ropes will permit. Not unfrequently, indeed, the ponderous pulley-wheels are blown from the pit-head frame, and carried to a considerable distance in the bosom of a thick cloud of coals and coal dust brought up from the mine by the fire-damp, whose explosion shakes absolutely the superincumbent solid earth itself, with a mimic earthquake. The dust of the ruins is sometimes thrown to such a height above the pit as to obscure the light of the sun. The silence which succeeds to this awful turmoil is no less formidable; for the atmospheric back-draught, rushing down the shaft, denotes the consumption of vital air in the mine, and the production of the deleterious choke-damp and azote.

Though many of the miners may have escaped by their distance in the workings from the destructive blast and the fire, yet their fate may perhaps be more deplorable. They hear the explosion, and are well aware of its certain consequences. Every one, anxious to secure his personal safety, strains every faculty to reach the pit-bottom. As the lights are usually extinguished by the explosion, they have to grope their way in utter darkness. Some have made most marvellous escapes, after clambering over the rubbish of fallen roofs, under which their companions are entombed; but others, wandering into uncertain alleys, tremble lest they should encounter the pestilential airs. At last they feel their power, and aware that their fate is sealed, they cease to struggle with their inevitable doom; they deliberately assume the posture of repose, and fall asleep in death. Such has been too often the fate of the hardy and intelligent miners who immure themselves deep beneath the ground, and venture their lives for the comfort of their fellow-men; and such frequently is the ruinous issue of the best ordered and most prosperous mining concerns.

In such circumstances the mining engineers or coal viewers have a dangerous and difficult duty to perform. The pit into which they must descend as soon as possible, is rendered unsafe by many causes; by the wrecks of loose timber torn away by the eruption, or by the unrespirable gases; by the ignition perhaps of a portion of the coal itself, or by the flame of a blower of fire-damp; either of which would produce violent and repeated explosions whenever the gas may again accumulate to the proper degree. Such a predicament is not uncommon, and it is one against which no human skill can guard. Yet even here, the sense of duty, and the hope of saving some workmen from a lingering death by wounds or suffocation, lead this intrepid class of men to descend amid the very demons of the mine.

As soon as the ventilation is restored by temporary brattices, the stoppings and doors are rebuilt in a substantial manner, and the workings are resumed with the wonted activity. From an inspection of *fig.* 864, p. 1035, it is obvious that the stability of the main stopping *p*, is an important point; for which reason it is counterforted by strong walls of stone, to resist the explosive force of fire-damp.

When it is known that fire exists in the wastes, either by the burning of the small coal-dust along the roads, or from the ignition of the solid coal by a blower of gas, the inspection of the mine is incomparably more hazardous, as safety cannot be ensured for an instant; for if the extrication of gas be great, it rapidly accumulates, and whenever it reaches the place where the fire exists, a new explosion takes place. There have been examples of the most furious detonations occurring regularly after the interval of about an hour, and being thus repeated 36 times in less than two days, each eruption appearing at the pit mouth like the blast of a volcano. It would be madness for any one to attempt a descent in such circumstances. The only resource is to moat up the pit, and check the combustion by exclusion of atmospheric air, or to drown the workings by letting the water accumulate below ground.

When fire exists in the wastes, with less apparent risk of life, water is driven upon it by portable fire-extinguishing engines, or small cannon are discharged near the burning coal, and the concussion thus produced in the air sometimes helps to extinguish the flame.

Since the primary cause of these tremendous catastrophes is the accension of the explosive gases by the candle of the miner, it has been long a desideratum to procure light of such a nature as may not possess the power of kindling the fire-damp. The train of light producible from the friction of flint and steel, by a mechanism called *a steel mill*, has been long known, and afforded a tolerable gleam, with which the miners were obliged to content themselves in hazardous atmospheres.

It consists of a small frame of iron, mounted with a wheel and pinion, which give rapid rotation to a disk of hard steel placed upright, to whose edge a piece of flint is applied. The use of this machine entailed on the miner the expense of an attendant, called the miller, who gave him light. Nor was the light altogether safe, for occasionally the ignited shower of steel particles attained to a sufficient heat to set fire to the fire-damp.

At length the attention of the scientific world was powerfully attracted to the means of lighting the miner with safety, by an awful catastrophe which happened at Felling Colliery, near Newcastle, on the 25th May, 1812. This mine was working with great vigor, under a well-regulated system of ventilation, set in action by a furnace and air-tube, placed over a rise pit in elevated ground. The depth of winning was above 100 fathoms; 25 acres of coal had been excavated, and one pit was yielding at the rate of 1700 tons per week. At 11 o'clock in the forenoon the night shift of miners was relieved by the day shift; 121 persons were in the mine, at their several stations, when, at half-past 11, the gas fired, with a most awful explosion, which alarmed all the neighboring villages. The subterraneous fire broke forth with two heavy discharges from the dip-pit, and these were instantly followed by one from the rise-pit. A slight trembling, as from an earthquake, was felt for about half a mile round the colliery, and the noise of the explosion, though dull, was heard at from 3 to 4 miles' distance. Immense quantities of dust and small coal accompanied these blasts, and rose high into the air, in the form of an inverted cone. The heaviest part of the ejected matter, such as corves, wood, and small coal, fell near the pits; but the dust, borne away by a strong west wind, fell in a continuous shower a mile and a half from the pit. In the adjoining village of Heworth it caused a darkness like that of early twilight, covering the roads where it fell so thickly that the footsteps of passengers were imprinted in it. The heads of both shaft-frames were blown off, their sides set on fire, and their pulleys shattered to pieces. The coal-dust ejected from the rise-pit into the horizontal part of the ventilating tube, was about 3 inches thick, and speedily burnt to a cinder; pieces of burning coal, driven off the solid stratum of the mine, were also blown out of this shaft. Of the 121 persons in the mine at the time of the explosion, only 32 were drawn up the pit alive, 3 of whom died a few hours after the accident. Thus no less than 92 valuable lives were instantaneously destroyed by this pestilential fire damp. The scene of distress among the relatives at the pit mouth was indescribably sorrowful.

Dr. W. Reid Clanny, of Sunderland, was the first to contrive a lamp which might burn among explosive air without communicating flame to the gas in which it was plunged. This he effected, in 1813, by means of an air-tight lamp, with a glass front, the flame of which was supported by blowing fresh air from a small pair of bellows through a stratum of water in the bottom of the lamp, while the heated air passed out through water by a recurved tube at top. By this means the air within the lamp was completely insulated from the surrounding atmosphere. This lamp was the first ever taken into a body of inflammable air in a coal-mine, at the exploding point, without setting fire to the gas around it. Dr. Clanny made another lamp upon an improved plan, by introducing into it the steam of water generated in a small vessel at the top of the lamp, heated by the flame. The chief objection to these lamps is their inconvenience in use.

Various other schemes of safe-lamps were offered to the miner by ingenious mechanicians, but they have been all superseded by the admirable invention of Sir H. Davy, founded on his fine researches upon flame. The lamp of Davy was instantly tried and approved of by Mr. Buddle and the principal mining engineers of the Newcastle district. A perfect security of accident is therefore afforded to the miner in the use of a lamp which transmits its light, and is fed with air, through a cylinder of wire gauze; and this invention has the advantage of requiring no machinery, no philosophical knowledge to direct its use, and is made at a very cheap rate.

In the course of a long and laborious investigation on the properties of the fire-damp, and the nature and communication of flame, Sir H. Davy ascertained that the explosions of inflammable gases were incapable of being passed through long narrow metallic tubes; and that this principle of security was still obtained by diminishing their length and diameter at the same time, and likewise diminishing their length, and increasing their number, so that a great number of small apertures would not pass an explosion, when their depth was equal to their diameter. This fact led him to trials upon sieves made of wire-gauze, or metallic plates perforated with numerous small holes; and he found it was impossible to pass explosions through them.

The apertures in the gauze should never be more than 1-20th of an inch square. In the working models sent by Sir H. to the mines, there were 748 apertures in the square inch, and the wire was about the 40th of an inch diameter. The cage or cylinder of wire-gauze should be made by double joinings, the gauze being folded over in such a manner as to leave no apertures. It should not be more than two inches in diameter; for in large cylinders the combustion of the fire-damp renders the top inconveniently hot; and a double top is always a proper precaution, fixed at a distance of about half an inch above the first top. The gauze cylinder should be fastened to the lamp by a screw of 4 or 5 turns. All joinings in the lamp should be made with hard solder; and the security depends upon the condition, that no aperture exists in the apparatus larger than in the wire gauze.

The forms of the lamp and cage, and the mode of burning the wick, may be greatly diversified; but the principle which ensures their safety must be strictly attended to. See Lamp of Davy, Safety Lamp, and Ventilation.

The state of the air in coal mines, from very early periods till the discovery of the safe-lamp, was judged of by the appearances exhibited by the flame of a candle; and this test must in many circumstances be still had recourse to. When there is merely a defect of atmospheric oxygen, the air being also partially vitiated by a little carbonic acid, either from choke-damp or the lungs and candles of the miners, the lights burn with a very dull flame, the tallow ceases to melt in the cup formed round the wick, till the flame flickers and expires. In this case the candle may be kept burning by slanting it more or less towards a horizontal position, which causes the tallow to melt with the edge of the flame. The candle is thus rapidly wasted, however; and therefore an oil lamp is preferable, as it continues to burn where a candle would be extinguished. The candles of the collier are generally small, with a very small wick; such being found to produce a more distinct flame than candles of a large size with a thick wick.

In trying the quality of the air by the flame of a candle, the wick must be trimmed by taking off the snuff, so as to produce a clear, distinct, and steady burning flame. When a candle thus trimmed is looked at in common air, a distinct and well-defined cone of flame is seen, of a fine sky-blue at the bottom next the wick, and thence of a bright yellow to the apex of the cone. Besides this appearance, there is another, surrounding the cone, which the brightness of the flame prevents the eye from discerning. This may be seen by placing one of the hands expanded as a screen betwixt the eyes and the candle, and at the distance of about an inch, so that the least point of the apex of the yellow flame may be seen, and no more. By this method, a top, as the miners term it, will be distinctly observed close to the apex of the yellow flame, from an eighth to a quarter of an inch in length. This top is of a yellowish-brown color, and like a misty haze. This haze is seen not only on the top, but it extends downwards and surrounds the flame fully half way, about a twentieth of an inch in thickness; here it assumes a violet color, which passes into a beautiful blue at the bottom next the wick. The test of the state of the air in mines, or "trying the candle," as practised by miners, depends entirely on the appearance which this haze assumes in shape and color at the top of the flame. In fact, this top has distinct appearances when burning in atmospheric air, carbonated air, azotized air, or fire-damp air; displaying many modifications, according to the proportions of the various admixtures.

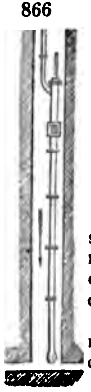
When azote or carbonic acid abounds, the top is frequently an inch or two in length, of a decided brown color, and the flame is short and dim. When they are still more copious, the flame goes out, and the miners immediately retire.

When inflammable air is imagined to exist in considerable quantity, the miner trims his candle, and advances with cautious step, holding the candle with the left hand, and screening the flame with the right; and as the fire-damp floats in the upper part of the gallery next the roof, he holds the candle as low as he can, and keeping his eye fixed on the tip, he moves forwards. If the gas be small in quantity, he may reach the forehead without observing any material change in his light. But if in his advance he perceives the tip to elongate, and take a bluish-gray color, he is put on his guard, and steps on with much caution; and if the tip begins to spire, he drops down on one knee, and holding the candle near the pavement, gradually raises it up, and watches the change it undergoes as it approaches the roof. If the gas be copious, the flame elongates into a sharp spire, as well as the top. It is in general reckoned dangerous when the tip changes from the bluish-gray to a fine blue color, accompanied with minute luminous points, which pass rapidly upwards through the flame and top. When the symptoms are manifestly dangerous, a sudden movement of the hands or body is liable to produce ignition by agitation of the fire-damp. The experienced miner therefore slowly and cautiously lowers his candle to the pavement, and then turning round, effects his retreat slowly, or slips up his right hand and extinguishes the flame with his finger and thumb. Should he venture too far, and approach the body of gas in an explosive condition, the tip of the candle rapidly elongates, and the whole rises in a sharp spire several inches in length; and then the whole surrounding atmosphere is in a blaze, an explosion ensues, and destructive ravage is the consequence, to an extent proportioned to the quantity of fire-damp. See Safety Lamp, and Ventilation.

This *trying the candle* is a delicate operation, requiring much practical sagacity, where the lives of so many men, and the welfare of the whole establishment, are at stake. Almost every colliery, after having been worked for some time, gives a peculiar top to the candle; so that while in one mine liable to fire-damp an explosion will take place with a top less than an inch long, in another mine the top may be two inches high, and yet the air be considerably under the point of accension. These differences depend on several particulars. If the gas has not passed through a long course of ventilation, and is little mixed with air, it will ignite with a very short top; while, on the other hand, a gas which has run through a ventilation of 20 or 30 miles may cause the production of a long top without hazard. It is hence obvious, that skilful experience, and thorough practical knowledge, are the only sure guides in these cases.

We shall now describe briefly the modern modes of working coals a-dipping of, and deeper than, the engine-pit bottom. One of these consists in laying a working pump barrel with a long wind-bore at the bottom of the downset mine, furnished with a smooth rod working through a collar at the top of the working barrel. At one side of this, near the top, a kneed pipe is attached, and from it pipes are carried to the point of delivery, either at the engine pit bottom or day level, as represented in *fig.* 866. The spears are worked sometimes by rods connected with the machinery at the surface; in which case the spears, if very long, are either suspended from swing or pendulum rods, or move on friction rollers. But since the action of the spears, running with great velocity the total length of the engine stroke, very soon tears every thing to pieces, the motion of the spears under ground has been reduced from 6 or 8 feet, the length of the engine stroke, to about 15 inches; and the due speed in the pump is effected by the centring of a beam, and the attachment of the spears to it, as represented in *fig.* 867, where *a* is the working barrel, *b* the beam centred at *c*, having an arc-head and martingale sinking-chain. The spears *d* are fastened by a strong bolt, which passes through the beam; and there are several holes, by means of which the stroke in the pumps can be lengthened or shortened at convenience. The movement of the spears is regulated by a strong iron quadrant or wheel at the bottom.

866



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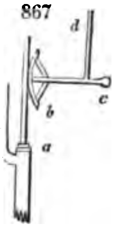
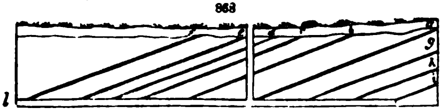


In level-free coals, these pumps may be worked by a water-wheel, stationed near the bottom of the pit, impelled by water falling down the shaft, to be discharged by the level to the day (day-level).

But the preferable plan of working under-dip coal, is that recently adopted by the Newcastle engineers; and consists in running a mine a-dipping of the engine-pit, in such direction of the dip as is most convenient; and both coals and water are brought up the rise of the coal by means of high-pressure engines, working with a power of from 30 to 50 pounds on the square inch. These machines are quite under command, and, producing much power in little space, they are the most applicable for underground work. An excavation is made for them in the strata above the coal, and the air used for the furnace under the boiler, is the returned air of the mine ventilation. In the dip-mine a double tram-road is laid; so that while a number of loaded corves are ascending, an equal number of empty ones are going down. Although this improved method has been introduced only a few years back, under-dip workings have been already executed more than an English mile under-dip of the engine-pit bottom, by means of three of these high-pressure engines, placed at equal distances in the under-dip mine. It may hence be inferred, that this mode of working is susceptible of most extensive application; and in place of sinking pits of excessive depth upon the dip of the coal, at an almost ruinous expense, much of the under-dip coal will in future be worked by means of the actual engine-pits. In the Newcastle district, coals are now working in an engine pit 115 fathoms deep under-dip of the engine-pit bottom, above 1600 yards, and fully 80 fathoms of perpendicular depth more than the bottom of the pit.

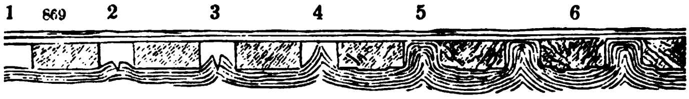
If an engine-pit be sunk to a given coal at a certain depth, all the other coals of the coal-field, both above and below the coal sunk to, can be drained and worked to the same depth, by driving a level cross-cut mine, both to the dip and rise, till all the coals are intersected, as represented in *fig.* 868, where A is the engine-pit bottom reaching to the coal *a*; and *b*, *c*, *d*, *e*, *f*, coals lying above the coal *a*; the coals which lie below it, *g*, *h*, *i*; *k* is the forehead of the cross-cut mine, intersecting all the lower coals; and *l*, the other forehead of the mine, intersecting all the upper coals.

868



In the "Report from the select committee of the House of Lords, appointed to take into consideration the state of the coal trade in the United Kingdom," printed in June, 1829, under the head of Mr. Buddle's evidence we have an excellent description of the and progress of creeps, which we have adverted to in the preceding account. ıexed *fig.* 869 exhibits the creep in all its progressive stages, from its commence- ıtil it has completely closed all the workings, and crushed the pillars of coal. :tion of the figures supposes us standing on the level of the different galleries re opened in the seam. The black is the coal pillars between each gallery; when e weakened too much, or, in other words, when their bases become too narrow for ement below, by the pressure of the incumbent stratification, they sink down into ɜment, and the first appearance is a little curvature in the bottom of each gallery: he first symptom obvious to sight; but it may generally be heard before it is seen. :t stage is when the pavement begins to open with a crack longitudinally. The ıge is when that crack is completed, and it assumes the shape of a metal ridge. :t is when the metal ridge reaches the roof. The next stage is when the peak ɪetal ridge becomes flattened by pressure, and forced into a horizontal direction, ɔmes quite close; just at this moment the coal pillars begin to sustain part of the :. The next is when the coal pillars take part of the pressure. The last stage it is dead and settled; that is, when the metal or factitious ridge, formed by the of the pillar into the pavement, bears, in common with the pillars of coal on each full pressure, and the coal becomes crushed or cracked, and can be no longer except by a very expensive and dangerous process. *Fig.* 869.

869



ˑst stage of active creep.
:ond do.
ird do.
urth do.
5. The metal ridge closed, and the creep beginning to settle.
6. The creep settled, the metal ridges being closely compressed, and supporting the roof.

ɪuantity of coals, cinders, and culm shipped coastwise, and exported from the ɔorts of the United Kingdom in the year 1837, was 8,204,301 tons; in 1836, the was 7,389,272 tons, being an increase of 815,029 tons, or 11·03 per cent. in 1837.

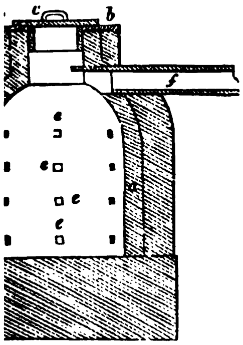
ollowing TABLE shows the separate proportions of this quantity supplied by and Wales, Scotland and Ireland:—

	1836.	1837.	Increase.
	Tons.	Tons.	Tons.
land and Wales -	6,757,937	7,570,254	812,317 or 12·02 per cent.
:land - - -	624,308	626,532	2,204 - 0·36
ınd - - -	7,027	7,515	488 - 6·94
Total - -	7,389,272	8,204,301	815,029 or 11·03 per cent.

ⅮAL, COKING OF. See also CHARCOAL.

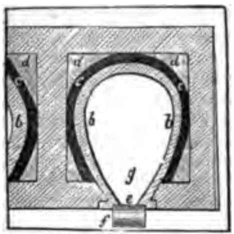
70 represents a *shachtofen*, or pit-kiln, for coking coals in Germany. *a* is the lining (*chemise*), made of fire-bricks; the enclosing walls are built of the same material; *b*, *b*, is a cast-iron ring covered with a cast-iron plate *c*. The floor of the kiln is massive. The coals are introduced, and the coke taken out, through a hole in the side *d*; during the process it is bricked up, and closed with an iron door. In the surrounding walls are 4 horizontal rows of flues *e*, *e*, *e*, *e*, which are usually iron pipes; the lowest row is upon a level with the floor of the kiln; and the others are each respectively one foot and a half higher than the preceding. Near the top of the shaft there is an iron pipe *f*, of from 8 to 10 inches in diameter, which allows the incoercible vapors generated in the coking to escape into the condenser, which consists either of wood or brick chambers. For kindling the coal, a layer of wood is first placed on the bottom of the kiln.

870



ɔking of small coal is performed upon vaulted hearths, somewhat like bakers' ıt with still flatter roofs. Of such kilns, several are placed alongside one another, each being an ellipse deviating little from a circle, so that the mouth may project but a small space. The dimensions are such, that from 10 to 12 cubic feet of coal-culm may be spread in a layer 6 inches deep upon the sole of the furnace. The top of the flat arch of fire brick should be covered with a stratum of loam and sand.

871



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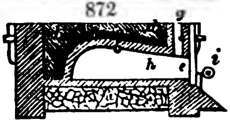
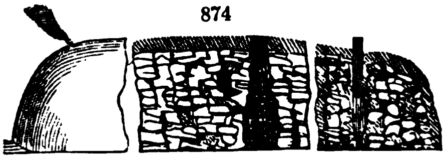


Figs. 871 and 872 represent such a kiln as is mounted at Zabrze, in Upper Silesia, for coking small coal. *Fig.* 871 is the ground plan; *fig.* 872 the vertical section in the line of the long axis of *fig.* 871. *a*, is the sand-bed of the hearth, under the brick sole; *b*, is the roof of large fire-bricks; *c*, the covering of loam; *d*, the top surface of sand; *e*, the orifice in the front wall, for admission of the culm, and removal of the coke, over the sloping stone *f*. The flame and vapors pass off above this orifice, through the chimney marked *g*, or through the aperture *h*, into a lateral chimney. *i*, is a bar of iron laid across the front of the door, as a fulcrum to work the iron rake upon. A layer of coals is first kindled upon the hearth, and when this is in brisk ignition, it is covered with the culm in successive sprinklings. When the coal is sufficiently coked, it is raked out, and quenched with water.

Fig. 873 represents a simple coking *meiler* or *mound*, constructed in a circular form round a central chimney of loose bricks, towards which small horizontal flues are laid among the lumps of coals. The sides and top are covered with culm or slack, and the heap is kindled from certain openings towards the circumference. *Fig.* 874 represents an oblong *meiler*, sometimes made 100 or 150 feet in length, and from 10 to 12 in breadth. The section in the middle of the figure shows how the lumps are piled up; the wooden stakes are lifted out when the heap is finished, in order to introduce kindlings at various points; and the rest of the meiler is then covered with slack and clay, to protect it from the rains. A jet of smoke and flame is seen issuing from its left end.

874



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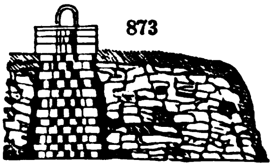
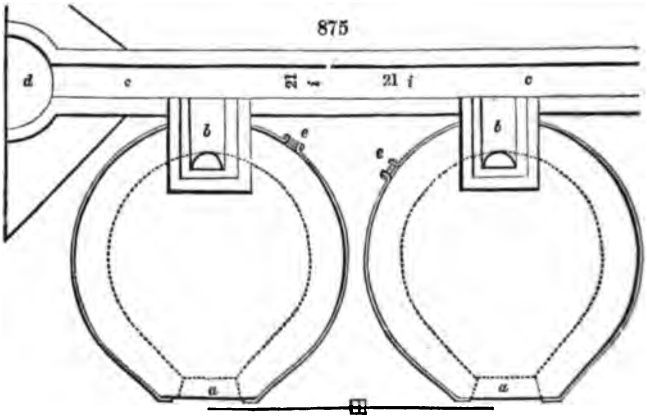


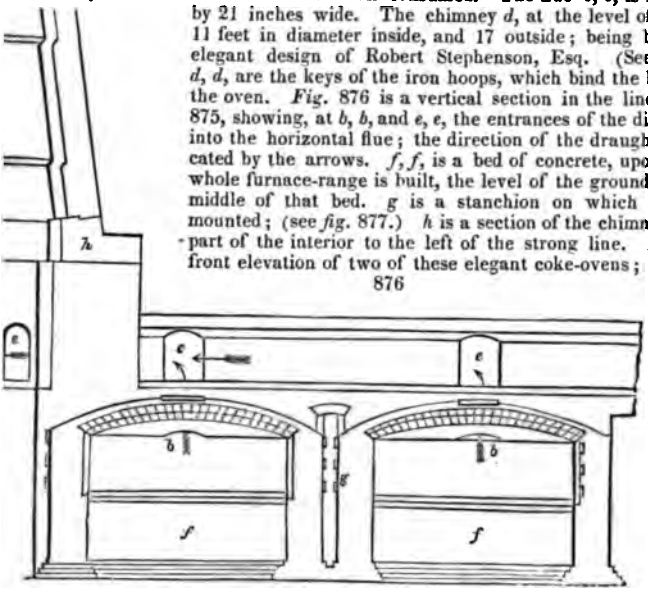
An excellent range of furnaces for making a superior article of coke, for the service of the locomotive engines of the London and Birmingham Railway Company, has been recently erected at the Camden Town station; consisting of 18 ovens in two lines, the whole discharging their products of combustion into a horizontal flue, which terminates in a chimney-stalk, 115 feet high. *Fig.* 875 is a ground plan of the elliptical ovens, each being 12 feet by 11 internally, and having 3 feet thickness of walls. *a*, *a*, is the mouth, 3½

875



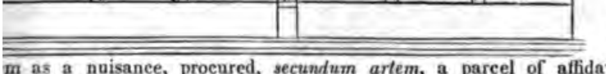
t wide outside, and about 2¾ feet within. *b, b,* are the entrances into the flue; they y be shut more or less completely by horizontal slabs of fire-brick, resting on iron frames, shed in from behind, to modify the draught of air. The grooves of these damper- bs admit a small stream of air to complete the combustion of the volatilized particles soot. By this means the smoke is well consumed. The flue *c, c,* is 2½ feet high, by 21 inches wide. The chimney *d*, at the level of the flue, is 11 feet in diameter inside, and 17 outside; being built from an elegant design of Robert Stephenson, Esq. (See CHIMNEY.) *d, d,* are the keys of the iron hoops, which bind the brickwork of the oven. *Fig.* 876 is a vertical section in the line A, B, of *fig.* 875, showing, at *b, b,* and *e, e,* the entrances of the different ovens into the horizontal flue; the direction of the draught being indicated by the arrows. *f, f,* is a bed of concrete, upon which the whole furnace-range is built, the level of the ground being in the middle of that bed. *g* is a stanchion on which the crane is mounted; (see *fig.* 877.) *h* is a section of the chimney wall, with part of the interior to the left of the strong line. *Fig.* 877 is a front elevation of two of these elegant coke-ovens; in which the cing hoops *i, i, i,* are shown; *k, k,* are the cast iron doors, strengthened outside with gonal ridges; each door being 5½ feet high, by 4 feet wide, and lined internally with -bricks. They are raised and lowered by means of chains and counterweights, moved the crane *l*.

876



Each alternate oven is charged, between 8 and 10 o'clock every morning, with 3½ tons good coals. A wisp of straw is thrown in on the top of the heap, which takes fire by radiation from the dome (which is in a state of dull ignition from the preceding opera- n), and inflames the smoke then rising from the surface, by the re-action of the hot sides and bottom upon the body of the fuel. In this way the smoke is consumed at the very commencement of the process, when it would otherwise be most abundant. A neighbor of the above coking ovens, having lately indicted m as a nuisance, procured, *secundum artem*, a parcel of affidavits from sundry mical and medical men. Two of the former, who had not entered the premises, but l espied the outside of the furnaces' range at some distance, declared that "the coking cess, as performed at the ovens, is a species of distillation of coal!" How rashly do practical theorists affirm what is utterly unfounded, and mislead an unscientific ge! That the said coking process is in no respect a species of distillation, but a nplete combustion of the volatile principles of the coal, will be manifest from the lowing description of its actual progress. The mass of coals is first kindled at the face, as above stated, where it is supplied with abundance of atmospheric oxygen; ause the doors of the ovens in front, and the throat-vents behind, are then left open.

877



The consequence is, that no more smoke is discharged from the top of the chimney, at this the most sooty period of the process, than is produced by an ordinary kitchen fire. In these circumstances, the coal gas, or other gas, supposed to be generated in the slightly heated mass beneath, cannot escape destruction in passing up through the bright open flame of the oven. As the coking of the coal advances most slowly and regularly from the top of the heap to the bottom, only one layer is affected at a time, and in succession downwards, while the surface is always covered with a stratum of redhot cinders, ready to consume every particle of carbureted or sulphureted hydrogen gases which may escape from below. The greatest mass, when calcined in this downward order, cannot emit into the atmosphere any more of the above-mentioned gases than the smallest heap; and therefore the argument raised on account of the magnitude of the operations, is altogether fallacious.

The coke being perfectly freed from all fuliginous and volatile matters by a calcination of upwards of 40 hours, is cooled down to moderate ignition by sliding in the dampers, and sliding up the doors, which had been partially closed during the latter part of the process. It is now observed to form prismatic concretions, somewhat like a columnar mass of basalt. These are loosened by iron bars, lifted out upon shovels furnished with long iron shanks, which are poised upon swing chains with hooked ends, and the lumps are thrown upon the pavement, to be extinguished by sprinkling water upon them from the rose of a watering-can; or, they might be transferred into a large chest of sheet-iron set on wheels, and then covered up. Good coals thus treated, yield 80 per cent. of an excellent compact glistening coke; weighing about 14 cwt. per chaldron.

The loss of weight in coking in the ordinary ovens is usually reckoned at 25 per cent.; and coal, which thus loses one fourth in weight, gains one fourth in bulk.

Laborers who have been long employed at rightly-constructed coke ovens, seem to enjoy remarkably good health.

PITTACALL is one of the 6 curious principles detected in wood-tar by Reichenbach. It is a dark-blue solid substance, somewhat like indigo, assumes a metallic fiery lustre on friction, and varies in tint from copper to golden. It is void of taste and smell, not volatile; carbonizes at a high heat without emitting an ammoniacal smell; is soluble or rather very diffusible in water; gives a green solution with a cast of crimson, in sulphuric acid, with a cast of red blue, in muriatic acid, and with a cast of aurora red, in acetic acid. It is insoluble in alkalis. It dyes a fast blue upon linen and cotton goods, with tin and aluminous mordants.

PLASTER; See MORTAR.

PLASTER OF PARIS; see GYPSUM.

PLATED MANUFACTURE. (*Fabrique de plaqué*, Fr.; *Silber plattirung*, Germ.) The silver in this case is not applied to ingots of pure copper, but to an alloy consisting of copper and brass, which possesses the requisite stiffness for the various articles.

The furnace used for melting that alloy, in black-lead crucibles, is a common air-furnace, like that for making brass.

The ingot-moulds are made of cast-iron, in two pieces, fastened together; the cavity being of a rectangular shape, 3 inches broad, 1½ thick, and 18 or 20 long. There is an elevated mouth-piece or gate, to give pressure to the liquid metal, and secure solidity to the ingot. The mould is heated, till the grease with which its cavity is besmeared merely begins to smoke, but does not burn. The proper heat of the melted metal for casting, is when it assumes a bluish color, and is quite liquid. Whenever the metal has solidified in the mould, the wedges that tighten its rings are driven out, lest the shrinkage of the ingot should cause the mould to crack. See BRASS.

The ingot is now dressed carefully with the file on one or two faces, according as it is to be single or double plated. The thickness of the silver plate is such as to constitute one fortieth of the thickness of the ingot; or when this is an inch and a quarter thick, the silver plate applied is one thirty-second of an inch; being by weight a pound troy of the former, to form 8 to 10 pennyweights of the latter. The silver, which is slightly less in size than the copper, is tied to it truly with iron wire, and a little of a saturated solution of borax is then insinuated at the edges. This salt melts at a low heat, and excludes the atmosphere, which might oxydize the copper, and obstruct the union of the metals. The ingot thus prepared is brought to the plating furnace.

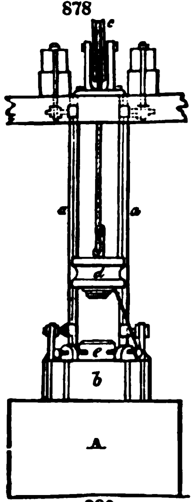
The furnace has an iron door with a small hole to look through; it is fed with cokes, laid upon a grate at a level with the bottom of the door. The ingot is placed immediately upon the cokes, the door is shut, and the plater watches at the peep-hole the instant when the proper soldering temperature is attained. During the union of the silver and copper, the surface of the former is seen to be drawn into intim[illegible]y contact with the latter, and this species of *riveting* is the signal for removing the compound bar instantly from the furnace. Were it to remain a very little longer, the silver would become alloyed with the copper, and the plating be thus completely spoiled. The adhesion is, in fact, accomplished here by the formation of a film of true silver-solder at the surfaces of contact.

The ingot is next cleaned, and rolled to the proper thinness between cylinders as described under Mint; being in its progress of lamination frequently annealed on a small reverberatory hearth. After the last annealing, the sheets are immersed in hot dilute sulphuric acid, and scoured with fine Calais sand; they are then ready to be fashioned into various articles.

In plating copper wire, the silver is first formed into a tubular shape, with one edge projecting slightly over the other; through which a redhot copper cylinder being somewhat loosely run, the silver edges are closely pressed together with a steel burnisher, whereby they get firmly united. The tube, thus completed, is cleaned inside, and put on the proper copper rod, which it exactly fits. The copper is left a little longer than its coating tube, and is grooved at the extremities of the latter, so that the silver edges, being worked into the copper groove, may exclude the air from the surface of the rod. The compound cylinder is now heated redhot, and rubbed briskly over with the steel burnisher in a longitudinal direction, whereby the two metals get firmly united, and form a solid rod, ready to be drawn into wire of any requisite fineness and form; as flat, half-round, fluted, or with mouldings, according to the figure of the hole in the draw-plate. Such wire is much used for making bread-baskets, toast-racks, snuffers, and articles combining elegance with lightness and economy. The wire must be annealed from time to time during the drawing, and finally cleaned, like the plates, with dilute acid.

Formerly the different shaped vessels of plated metal were all fashioned by the hammer; but every one of simple form is now made in dies struck with a drop-hammer or stamp. Some manufacturers employ 8 or 10 drop machines.

878



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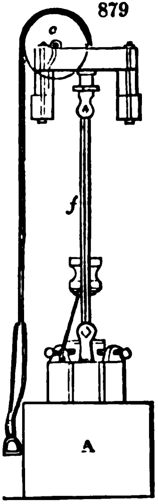
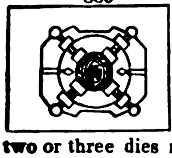


Figs. 878 and 879 are two views of the stamp. A is a large stone, the more massy the better; *b*, the anvil on which the die *e* is secured by four screws, as shown in the ground plan, *fig.* 880. In *fig.* 878, *a a* are two upright square prisms, set diagonally with the angles opposed to each other; between which the hammer or drop *d* slides truly, by means of nicely fitted angular grooves or recesses in its sides. The hammer is raised by pulling the rope *f*, which passes over the pulley *c*, and is let fall from different heights, according to the impulse required. Vessels which are less in diameter at the top and bottom than in the middle, must either be raised by the stamp in two pieces, or raised with a hand hammer. The die is usually made of *cast* steel. When it is placed upon the anvil, and the plated metal is cut into pieces of proper size, the top of the die is then surrounded with a lute made of oil and clay, for an inch or two above its surface; and the cavity is filled with melted lead. The under face of the stamp-hammer has a plate of iron called the *licker-up* fitted into it, about the area of the die. Whenever the lead has become solid, the hammer is raised to a certain height, and dropped down upon it; and as the under face of the licker-up is made rough like a rasp, it firmly adheres to the lead, so as to lift it afterward with the hammer. The plated metal is now placed over the die, and the hammer mounted with its lead is let fall repeatedly upon it, till the impression on the metal is complete. If the vessel to be struck be of any considerable depth, two or three dies may be used, of progressive sizes in succession. But it occasionally happens that when the vessel has a long conical neck, recourse must be had to an auxiliary operation, called *punching*. See the embossing punches, *fig.* 881. These are made of cast steel, with their hollows turned out in the lathe. The pieces *a*, *b* are of lead. The punching is performed by a series of these tools, of different sizes, beginning with the largest, and ending with the least. By this means a hollow cone, 3 or 4 inches deep, and an inch diameter, may be raised out of a flat plate. These punches are struck with a hand hammer also, for small articles, of too great delicacy for the drop. Indeed, it frequently happens that one part of an article is executed by the stamp, and another by the hand.

880



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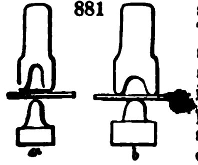
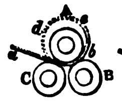


Cylindrical and conical vessels are mostly formed by bending and soldering. The bending is performed on blocks of wood, with wooden mallets; but the machine so much used by the tin-smiths, to form their tubes and cylindric vessels (see the end section, *figs.* 882 and 883), might be employed with advantage. This consists of 3 iron rollers fixed in an iron frame. A, B, C, are the three cylinders, and *a*, *b*, *c*, *d*, the riband or sheet of metal passed through them to receive the cylindrical or conical curvature. The upper roller A can be raised or lowered at pleasure, in order to modify the diameter of the tube; and when one end of the roller is higher than the other, the conical curvature is given. The edges of the plated cylinders or cones are soldered with an alloy composed of silver and brass. An alloy of silver and copper is somewhat more fusible; but that of brass and silver answers best for plated metal, the brass being in very small proportion, lest the color of the plate be affected. Calcined borax mixed with sandiver (the salt skimmed from the pots of crown glass) is used along with the alloy, in the act of soldering. The seam of the plated metal being smeared with that saline mixture made into a pap with water, and the bits of laminated solder, cut small with scissors, laid on, the seam is exposed to the flame of an oil blowpipe, or to that of charcoal urged by bellows in a little forge-hearth, till the solder melts and flows evenly along the junction. The use of the sandiver seems to be, to prevent the iron wire that binds the plated metal tube from being soldered to it.

882



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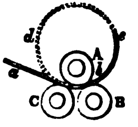
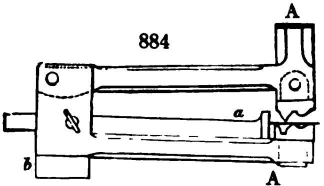


Mouldings are sometimes formed upon the edges of vessels, which are not merely ornamental, but give strength and stiffness. These are fashioned by an instrument called a *swage*, represented in *figs.* 884 and 885. The part A lifts up by a joint, and the metal to be *swaged* is placed between the dies, as shown in the figures; the tail *b* being held in the jaws of a vice, while the shear-shaped hammer rests upon it. By striking on the head A, while the metal plate is shifted successively forwards, the beading is formed. In *fig.* 884 the tooth *a* is a guide to regulate the distance between the bead and the edge. A similar effect is produced of late years in a neater and more expeditious manner by the rollers, *figs.* 885, 886. *Fig.* 888 is a section to show the form of the bead. The two wheels *a*, *a*, *fig.* 886, are placed upon axes, two of which are furnished with toothed pinions in their middle; the lower one, being turned by the handle, gives motion to the upper. The groove in the upper wheel corresponds with the bead in the lower, so that the slip of metal passed through between them assumes the same figure.

884



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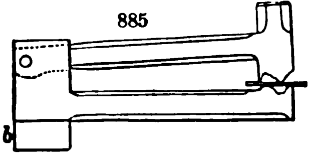

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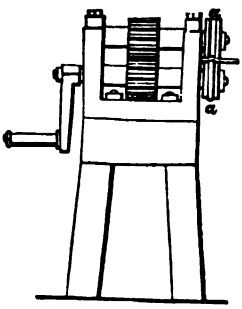

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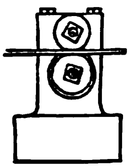
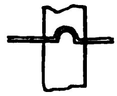


888



The greatest improvement made in this branch of manufacture, is the introduction of silver edges, beads, and mouldings, instead of the plated ones, which from their prominence had their silver surface speedily worn off, and thus assumed a brassy look. The silver destined to form the ornamental edgings is laminated exceedingly thin; a square inch sometimes weighing no more than 10 or 12 grains. This is too fragile to bear the action of the opposite steel dies of the swage above described. It is necessary, therefore, that the sunk part of the die should be steel, and the opposite side lead, as was observed in the stamping; and this is the method now generally employed to form these silver ornaments. The inside shell of this silver moulding is filled with soft solder, and then bent into the requisite form.

The base of candlesticks is generally made in a die by the stamp, as well as the neck, the dish part of the nozzle or socket, and the tubular stem or pillar. The different parts are united, some with soft and others with hard solder. The branches of candlesticks are formed in two semi-cylindrical halves, like the feet of tea-urns. When an article is to be engraved on, an extra plate of silver is applied at the proper part, while the plate is still flat, and fixed by burnishing with great pressure over a hot anvil. This is a species of welding.

The last finish of plated goods is given by burnishing-tools of bloodstone, fixed in sheet-iron cases, or hardened steel, finely polished.

The ingots for lamination might probably be plated with advantage by the delicate pressure process employed for silvering copper wire.

The total value of the plate, plated ware, jewellery, and watches, exported in the year 1836, was 338,889*l.*; but the value of the plated goods is not given in the tables of revenue. M. Parquin, the greatest manufacturer of plated goods in Paris (or France, for this business is monopolized by the capital), who makes to the value of 700,000 francs per annum, out of the 1,500,000 which, he says, is the whole internal consumption of the kingdom, states that the internal consumption of the United Kingdom amounts to 30,000,000, or 20 times that of France! He adds, that our common laminated copper costs 26 sous the pound, while theirs costs 34. Their plated goods are fashioned, not in general with stamps, but by the pressure of tools upon wood moulds in the turning lathe, which is a great economy of capital to the manufacturer. There are factories at Birmingham which possess a heavy stock of 300,000 different die-moulds. See Stamping of Metals.

PLATINA-MOHR. The following easy method of preparing igniferous black platinum, proposed thirty years ago by Descotil, has been recently recommended by M. Dobereiner:—

Melt platina ore with double its weight of zinc, reduce the alloy to powder, and treat it first with dilute sulphuric acid, and next with dilute nitric acid, to oxydize and dissolve out all the zinc, which, contrary to one's expectations, is somewhat difficult to do, even at a boiling heat. The insoluble black-gray powder contains some osmiuret of iridium, united with the crude platinum. This compound acts like simple platina-black, after it has been purified by digestion in potash ley, and washing with water. Its oxydizing power is so great, as to transform not only the formic acid into the carbonic, and alcohol into vinegar, but even some osmic acid, from the metallic osmium. The above powder explodes by heat like gunpowder.

When the platina-*mohr* prepared by means of zinc is moistened with alcohol, it becomes incandescent, and emits osmic acid; but if it be mixed with alcohol into a paste, and spread upon a watch-glass, nothing but acetic acid will be disengaged; affording an elegant means of diffusing the odor of vinegar in an apartment.

PLATINUM is a metal of a grayish-white color, resembling in a good measure polished steel. It is harder than silver, and of about double its density, being of specific gravity 21. It is so infusible, that no considerable portion of it can be melted by the strongest heats of our furnaces. It is unchangeable in the air and water; nor does a white heat impair its polish. The only acid which dissolves it, is the nitro-muriatic; the muriate or chloride thus formed, affords, with pure ammonia or sal ammoniac, a triple salt in a yellow powder, convertible into the pure metal by a red heat. This character distinguishes platinum from every other metal.

Native Platinum.—In the natural state it is never pure, being alloyed with several other metals. It occurs only under the form of grains, which are usually flattened, and resemble in shape the gold *pepitas*. Their size is in general less than linseed, although in some cases they equal hempseed, and, occasionally, peas. One piece brought from Choco, in Peru, and presented to the Cabinet of Berlin, by M. Humboldt, weighs 55 grammes = 850 grains, or nearly 2 oz. avoirdupois. The greatest lump of native platinum known, till of late years, was one in the Royal Museum of Madrid, which was found in 1814 in the gold mine of Condoto, province of Novita, at Choco. Its size is greater than a turkey's egg, (about 2 inches one diameter, and 4 inches the other,) and its weight 760 grammes, = 24 oz., or fully 2 lbs. troy. See *infrà.*

The color of the grains of native platinum is generally a grayish-white, like tarnished steel. The cavities of the rough grains are often filled with earthy and ferruginous matters, or sometimes with small grains of black oxyde of iron, adhering to the surface of the platinum grains. Their specific gravity is also much lower than that of forged pure platinum; varying from 15 in the small particles, to 18·94 in M. Humboldt's large specimen. This relative lightness is owing to the presence of iron, copper, lead, and chrome; besides its other more lately discovered metallic constituents, palladium, osmium, rhodium, and iridium.

Its main localities in the New Continent, are in the three following districts:—

1. At Choco, in the neighborhood of Barbacoas, and generally on the coasts of the South Sea, or on the western slopes of the Cordillera of the Andes, between the 2d and the 6th degrees of north latitude. The gold-washings that furnish most platinum, are those of Condoto, in the province of Novita; those of Santa Rita, or Viroviro, of Santa Lucia, of the ravine of Iro, and Apoto, between Novita and Taddo. The deposite of gold and platinum grains is found in alluvial ground, at a depth of about 20

feet. The gold is separated from the platinum by picking with the hand, and also by amalgamation; formerly, when it was imagined that platinum might be used to debase gold, the grains of the former metal were thrown into the rivers, through which mistaken opinion an immense quantity of it was lost.

2. Platinum grains are found in Brazil, but always in the alluvial lands that contain gold, particularly in those of Matto-grosso. The ore of this country is somewhat different from that of Choco. It is in grains, which seem to be fragments of a spongy substance. The whole of the particles are nearly globular, exhibiting a surface formed of small spheroidal protuberances strongly cohering together, whose interstices are clean, and even brilliant.

This platinum includes many small particles of gold, but none of the magnetic iron-sand or of the small zircons which accompany the Peruvian ore. It is mixed with small grains of native palladium, which may be recognised by their fibrous or radiated structure, and particularly by their chemical characters.

3. Platinum grains are found in Hayti, or Saint Domingo, in the sand of the river Jacky, near the mountains of Sibao. Like those of Choco, they are in small brilliant grains, as if polished by friction. The sand containing them is quartzose and ferruginous. This native platinum contains, like that of Choco, chromium, copper, osmium, iridium, rhodium, palladium, and probably titanium. Vauquelin could find no gold among the grains.

Platinum has been discovered lately in the Russian territories, in the auriferous sands of Kuschwa, 250 wersts from Ekaterinebourg, and consequently in a geological position which seems to be analogous with that of South America.

These auriferous sands are, indeed, almost all superficial; they cover an argillaceous soil; and include, along with gold and platinum, débris of dolerite (a kind of green-stone), protoxyde of iron, grains of corundum, &c. The platinum grains are not so flat as those from Choco, but they are thicker; they have less brilliancy, and more of a leaden hue. This platinum, by M. Laugier's analysis, is similar in purity to that of Choco; but the leaden-gray grains, which were taken for a mixture of osmium and iridium, are merely an alloy of platinum, containing 25 per cent. of these metals.

The mines of Brazil, Columbia, and Saint Domingo furnish altogether only about 400 kilos. of platinum ore per annum; but those of Russia produce above 1800 kilos. The latter were discovered in 1822, and were first worked in 1824. They are all situated in the Ural mountains. The ore is disseminated in an argillaceous sand, of a greenish-gray color, resulting from the disintegration of the surrounding rocks, and constitutes from 1 to 3 parts in 4000 of the sand. Occasionally it has been found in lumps weighing 8 kilogrammes (16 lbs.!), but it generally occurs in blackish angular grains, which contain 70 per cent. of platinum, and 3 to 5 of iridium. The ore of Goro-Blagodatz is in small flattened grains, which contain 88 per cent. of this precious metal. The osmiure of iridium is found upon a great many points of the Urals, throughout a space of 140 leagues, being a product accessory to the gold washings. 32 kilogrammes of osmiure are collected there annually, which contain upon an average 2 per cent. of platinum.

M. Vauquelin found nearly ten per cent. of platinum in an ore of argentiferous copper, which was transmitted to him as coming from Guadalcanal in Spain. This would be the only example of platinum existing in a rock, and in a vein. As the same thing has not again been met with, even in other specimens from Guadalcanal, we must delay drawing geological inferences, till a new example has confirmed the authenticity of the first.

Platinum has been known in Europe only since 1748, though it was noticed by Ulloa in 1741. It was compared at first to gold; and was, in fact, brought into the market under the name of white gold. The term platinum, however, is derived from the Spanish word *plata*, silver, on account of its resemblance in color to that metal.

The whole of the platinum ore from the Urals is sent to St. Petersburg, where it is treated by the following simple process:—

One part of the ore is put in open platina vessels, capable of containing from 6 to 8 lbs., along with 3 parts of muriatic acid at 25° B. and 1 part of nitric acid at 40°. Thirty of these vessels are placed upon a sand-bath covered with a glazed dome with moveable panes, which is surmounted by a ventilating chimney to carry the vapors out of the laboratory. Heat is applied for 8 or 10 hours, till no more red vapors appear; a proof that the whole nitric acid is decomposed, though some of the muriatic remains. After settling, the supernatant liquid is decanted off into large cylindrical glass vessels, the residuum is washed, and the washing is also decanted off. A fresh quantity of nitro-muriatic acid is now poured upon the residuum. This treatment is repeated till the whole solid matter has eventually disappeared. The ore requires for solution from 10 to 15 times its weight of nitro-muriatic acid, according to the size of its grains.

The solutions thus made are all acid; a circumstance essential to prevent the iridium from precipitating with the platinum, by the water of ammonia, which is next added. The deposite being allowed to form, the mother waters are poured off, the precipitate is washed with cold water, dried, and calcined in crucibles of platinum.

The mother-waters and the washings are afterwards treated separately. The first being concentrated to one twelfth of their bulk in glass retorts, on cooling they let fall the iridium in the state of an ammoniacal chloride, constituting a dark-purple powder, occasionally crystallized in regular octahedrons. The washings are evaporated to dryness in porcelain vessels; the residuum is calcined and treated like fresh ore; but the platinum it affords needs a second purification.

For agglomerating the platinum, the spongy mass is pounded in bronze mortars; the powder is passed through a fine sieve, and put into a cylinder of the intended size of the ingot. The cylinder is fitted with a rammer, which is forced in by a coining press, till the powder be much condensed. It is then turned out of the mould, and baked 36 hours in a porcelain kiln, after which it may be readily forged, if it be pure, and may receive any desired form from the hammer. It contracts in volume from 1-6th to 1-5th during the calcination. The cost of the manufacture of platinum is fixed by the administration at 32 francs the Russian pound; but so great a sum is never expended upon it.

For Dr. Wollaston's process, see Phil. Trans. 1829, Part I.

Platinum furnishes most valuable vessels to both analytical and manufacturing chemists. It may be beat out into leaves of such thinness as to be blown about with the breath.

This metal is applied to porcelain by two different processes; sometimes in a rather coarse powder, applied by the brush, like gold, to form ornamental figures; sometimes in a state of extreme division, obtained by decomposing its muriatic solution, by means of an essential oil such as rosemary or lavender. In this case, it must be evenly spread over the whole ground. Both modes of application give rise to a steely lustre.

The properties possessed in common by gold and platinum, have several times given occasion to fraudulent admixtures, which have deceived the assayers. M. Vauquelin having executed a series of experiments to elucidate this subject, drew the following conclusions:—

If the platinum do not exced 30 or 40 parts in the thousand of the alloy, the gold does not retain any of it when the parting is made with nitric acid in the usual way; and when the proportion of platinum is greater, the fraud becomes manifest; 1st by the higher temperature required to pass it through the cupel, and to form a round button; 2. by the absence of the lightning, fulguration, or coruscation; 3. by the dull white color of the button and its crystallized surface; 4. by the straw-yellow color which platinum communicates to the aquafortis in the parting; 5. by the straw-yellow color, bordering on white, of the cornet, after it is annealed. If the platinum amounts to one fourth of the gold, we must add to the alloy at least 3 times its weight of fine silver, laminate it very thin, anneal somewhat strongly, boil it half an hour in the first aquafortis, and at least a quarter of an hour in the second, in order that the acid may dissolve the whole of the platinum.

Were it required to determine exactly the proportions of platinum contained in an alloy of copper, silver, gold, and platinum, the amount of the copper may be found in the first place by *cupellation*, then the respective quantities of the three other metals may be learned by a process founded, 1. upon the property possessed by sulphuric acid of dissolving silver without affecting gold or platinum; and, 2. upon the property of platinum being soluble in the nitric acid, when it is alloyed with a certain quantity of gold and silver.

According to Boussingault, the annual product of platinum in America does not exceed 8½ cwts. At Nischne-Tagilsk, in 1824, a lump of native platinum weighing fully 10 lbs. was found; and in 1830, another lump, of nearly double size, which weighed 35¾ Prussian marcs; fully 18 lbs. avoirdupois.

PRODUCTION OF PLATINUM IN THE URAL.

From 1822 to 1827 inclusively, 52 puds* and 22½ pounds.

1828	94	
1829	78	31½
1830	105	1
1831 to 1833	348	15

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* One pud = 40 Russian pounds, = 69,956 Prussian marcs (See SILVER); 1 pound = 96 zolotniks.

Analyses of the **Platinum Ores** of the Urals, and of that from Barbacoas on the Pacific, between the 2d and 6th degrees of northern latitude.

	From Nischne-Tagilsk. Berzelius.		Goroblagodat. Osann.		Barbacoas. Berzelius.
	Magnetic.	Not Magnetic.			
Platinum -	73·58	78·94	83·07	86·50	84·30
Iridium - -	2·35	4·97	1·91	—	1·46
Rhodium -	1·15	0·86	0·59	1·15	3·46
Palladium -	0·30	0·28	0·26	1·10	1·06
Iron - -	12·98	11·04	10·79	8·32	5·31
Copper - -	5·20	0·70	1·30	0·45	0·74
Undissolved Osmium and Iridium	2·30	1·96	1·80	1·40	—
Osmium -	—	—	—	—	1·03
Quartz - -	—	—	—	—	0·60
Lime - -	—	—	—	—	0·12
	97·86	98·75	99·72	98·92	98·08

PLUMBAGO. See Graphite, for its mineralogical and chemical characters. The mountain at Borrowdale, in which the black-lead is mined, is 2000 feet high, and the entrance to the mine is 1000 feet below its summit. This valuable mineral became so common a subject of robbery about a century ago, as to have enriched, it was said, a great many persons living in the neighborhood. Even the guard stationed over it by the proprietors was of little avail against men infuriated with the love of plunder; since in those days a body of miners broke into the mine by main force, and held possession of it for a considerable time.

The treasure is now protected by a strong building, consisting of four rooms upon the ground floor; and immediately under one of them is the opening, secured by a trapdoor, through which alone workmen can enter the interior of the mountain. In this apartment, called the dressing-room, the miners change their ordinary clothes for their working dress, as they come in, and after their six hours' post or journey, they again change their dress, under the superintendence of the steward, before they are suffered to go out. In the innermost of the four rooms, two men are seated at a large table, sorting and dressing the plumbago, who are locked in while at work, and watched by the steward from an adjoining room, who is armed with two loaded blunderbusses. Such formidable apparatus of security is deemed requisite to check the pilfering spirit of the Cumberland mountaineers.

The cleansed black-lead is packed up into strong casks, which hold 1 cwt. each. These are all despatched to the warehouse of the proprietors in London, where the black-lead is sold monthly by auction, at a price of from 35*s*. to 45*s*. a pound.

In some years, the net produce of the *six weeks'* annual working of the mine has, it is said, amounted to 30,000*l*. or 40,000*l*.

PLUSH (*Panne, Peluche*, Fr.; *Wollsammet, Plüsch*, Germ.) is a textile fabric, having a sort of velvet nap or shag upon one side. It is composed regularly of a woof of a single woollen thread, and a two-fold warp, the one, wool of two threads twisted, the other, goat's or camel's hair. There are also several sorts of plush made entirely of worsted. It is manufactured, like velvet, in a loom with three treadles; two of which separate and depress the woollen warp, and the third raises the hair-warp, whereupon the weaver, throwing the shuttle, passes the woof between the woollen and hair warp; afterwards, laying a brass broach or needle under that of the hair, he cuts it with a knife (see Fustian) destined for that use, running its fine slender point along in the hollow of the guide-broach, to the end of a piece extended upon a table. Thus the surface of the plush receives its velvety appearance. This stuff is also made of cotton and silk.

POINT NET is a style of lace formerly much in vogue, but now superseded by the bobbin-net manufacture.

PORCELAIN is the finest kind of pottery-ware. It is considered under that title.

PORPHYRY is a compound mineral or rock, composed essentially of a base of hornstone, interspersed with crystals of feldspar. It frequently contains also quartz, mica, and hornblende. That most esteemed is the ancient porphyry of Egypt, with a ground of a fine red color passing into purple, having snow-white crystals of feldspar imbedded in it. Most beautiful specimens of it are to be seen in the antique colossal statues in the British Museum.

Porphyry occurs in Arran, and in Perthshire between Dalnacardoch and Tummel bridge. It is much used for making slabs, mullers, and mortars.

PORTER is a malt liquor, so called from being the favorite beverage of the porters and workpeople of the metropolis and other large towns of the British empire; it is characterized by its dark-brown color, its transparency, its moderately bitter taste, and peculiar aromatic flavor, which, along with its tonic and intoxicating qualities, make it be keenly relished by thirsty palates accustomed to its use. At first the essential distinction of porter arose from its wort being made with highly-kilned brown malt, while other kinds of beer and ale were brewed from a paler article; but of late years, the taste of the public having run in favor of sweeter and lighter beverages, the actual porter is brewed with a less proportion of brown malt, is less strongly hopped, ahd not allowed to get hard by long keeping in huge ripening tuns. Some brewers color the porter with burnt sugar; but in general the most respectable concentrate a quantity of their first and best wort to an extract, in an iron pan, and burn this into a *coloring* stuff, whereby they can lay claim to the merit of using nothing in their manufacture but malt and hops. The singular flavor of good London porter seems to proceed, in a great degree, from that of the old casks and fermenting tuns in which it is prepared. Though not much addicted to vinous potations of any kind, I feel warranted by long experience to opine, that the porter brewed by the eminent London houses, when drunk in moderation, is a far wholesomer beverage for the people than the thin acidulous wines of France and Germany. See Beer.

PORTLAND STONE is a fine compact oolite, so named from the island where it is quarried. It is a convenient but not a durable building-stone.

POTATO (*Pomme de terre*, Fr.; *Kartoffel*, Germ.) is the well known root of the *Solanum tuberosum*.

The following Table exhibits several good analyses of the potato:—

Sort.	Fibrine.	Starch.	Veg. album.	Gum.	Acids and Salts.	Water.	Analyst.
Red potatoes - -	7·0	15·0	1·4	4·1	5·1	75·0	Einhof.
Id. germinated -	6·8	15·2	1·3	3·7	—	73·0	—
Potato sprouts - -	2·8	0·4	0·4	3·3	—	93·0	—
Kidney potatoes -	8·8	9·1	0·8	—	—	81·3	—
Large red do. - -	6·0	12·9	0·7	—	—	78·0	—
Sweet do. - -	8·2	15·1	0·8	—	—	74·3	—
Potato of Peru -	5·2	15·0	1·9	1·9		76·0	Lampad.
. England	6·8	12·9	1·1	1·7		77·5	—
Onion potato - -	8·4	18·7	0·9	1·7		70·3	—
. Voigtland	7·1	15·4	1·2	2·0		74·3	—
. cultivated in the . environs of Paris	6·79	13·3	0·92	3·3	1·4	73·12	Henry.

POTASH, or POTASSA. (*Potasse*, Fr.; *Kali*, Germ.) This substance was so named from being prepared for commercial purposes by evaporating in iron pots the lixivium of the ashes of wood fuel. In the crude state called potashes, it consists, therefore, of such constituents of burned vegetables as are very soluble in water, and fixed in the fire. The potash salts of plants which originally contained vegetable acids, will be converted into carbonates, the sulphates will become sulphites, sulphurets, or even carbonates, according to the manner of incineration; the nitrates will be changed into pure carbonates, while the muriates or chlorides will remain unaltered. Should quicklime be added to the solution of the ashes, a corresponding portion of caustic potassa will be introduced into the product, with more or less lime, according to the care taken in decanting off the clear ley for evaporation.

In America, where timber is in many places an incumbrance upon the soil, it is felled, piled up in pyramids, and burned, solely with a view to the manufacture of potashes. The ashes are put into wooden cisterns, having a plug at the bottom of one of the sides under a false bottom; a moderate quantity of water is then poured on the mass, and some quicklime is stirred in. After standing for a few hours, so as to take up the soluble matter, the clear liquor is drawn off, evaporated to dryness in iron pots, and finally fused at a red heat into compact masses, which are gray on the outside, and pink-colored within.

Pearlash is prepared by calcining potashes upon a reverberatory hearth, till the whole carbonaceous matter, and the greater part of the sulphur, be dissipated; then lixiviating the mass, in a cistern having a false bottom covered with straw, evaporating the clear ley to dryness in flat iron pans, and stirring it towards the end into white lumpy granulations.

I find the best pink Canadian potashes, as imported in casks containing about 5 cwts., to contain pretty uniformly 60 per cent. of absolute potassa; and the best pearl-ashes to contain 50 per cent.; the alkali in the former being nearly in a caustic state; in the latter, carbonated.

All kinds of vegetables do not yield the same proportion of potassa. The more succulent the plant, the more does it afford; for it is only in the juices that the vegetable salts reside, which are converted by incineration into alkaline matter. Herbaceous weeds are more productive of potash than the graminiferous species, or shrubs, and these than trees; and for a like reason, twigs and leaves are more productive than timber. But plants in all cases are richest in alkaline salts when they have arrived at maturity. The soil in which they grow also influences the quantity of saline matter.

The following TABLE exhibits the average product in potassa of several plants, according to the researches of Vauquelin, Pertuis, Kirwan, and De Saussure :—

In 1000 parts.	Potassa.	In 1000 parts.	Potassa.
Pine or fir	0·45	Dry beech bark	6·00
Poplar	0·75	Fern	6·26
Trefoil	0·75	Large rush	7·22
Beechwood	1·45	Stalk of maize	17·50
Oak	1·53	Bastard chamomile (*Anthemis cotula*, L.)	19·60
Boxwood	2·26		
Willow	2·85	Bean stalks	20·00
Elm and maple	3·90	Sunflower stalks	20·00
Wheat straw	3·90	Common nettle	25·03
Barb of oak twigs	4·20	Vetch plant	27·50
Thistles	5·00	Thistles in full growth	35·37
Flax stems	5·00	Dry straw of wheat before earing	47·00
Small rushes	5·08	Wormwood	73·00
Vine shoots	5·50	Fumitory	79·00
Barley straw	5·80		

Stalks of tobacco, potatoes, chestnuts, chestnut husks, broom, heath, furze, tansy, sorrel, vine leaves, beet leaves, orach, and many other plants, abound in potash salts. In Burgundy, the well-known *cendres gravelées* are made by incinerating the lees of wine pressed into cakes, and dried in the sun; the ashes contain fully 16 per cent. of potassa.

The purification of pearlash is founded upon the fact of its being more soluble in water than the neutral salts which debase it. Upon any given quantity of that substance, in an iron pot, let one and a half times its weight of water be poured, and let a gentle heat be applied for a short time. When the whole has again cooled, the bottom will be incrusted with the salts, while a solution of nearly pure carbonate of potash will be found floating above, which may be drawn off clear by a syphon. The salts may be afterwards thrown upon a filter of gravel. If this ley be diluted with 6 times its bulk of water mixed with as much slaked lime as there was pearlash employed, and the mixture be boiled for an hour, the potash will become caustic, by giving up its carbonic acid to the lime. If the clear settled lixivium be now syphoned off, and concentrated by boiling in a covered iron pan, till it assumes the appearance of oil, it will constitute the common caustic of the surgeon, the *potassa fusa* of the shops. But to obtain potassa chemically pure, recourse must be had to the bicarbonate, nitrate, or tartrate of potassa, salts which, when carefully crystallized, are exempt from any thing to render the potassa derived from them impure. The bicarbonate having been gently ignited in a silver basin, is to be dissolved in 6 times its weight of water, and the solution is to be boiled for an hour, along with one pound of slaked lime for every pound of the bicarbonate used. The whole must be left to settle without contact of air. The supernatant ley is to be drawn off by a syphon, and evaporated in an iron or silver vessel provided with a small orifice in its close cover for the escape of the steam, till it assumes, as above, the appearance of oil, or till it be nearly redhot. Let the fused potassa be now poured out upon a bright plate of iron, cut into pieces as soon as it concretes, and put up immediately in a bottle furnished with a well-ground stopper. It is hydrate of potassa, being composed of 1 atom of potassa 48, + 1 atom of water 9, = 57.

A pure carbonate of potassa may be also prepared by fusing pure nitre in an earthen crucible, and projecting charcoal into it by small bits at a time, till it ceases to cause deflagration. Or a mixture of 10 parts of nitre and 1 of charcoal may be deflagrated in small successive portions in a redhot deep crucible. When a mixture of 2 parts of tartrate of potassa, or crystals of tartar, and 1 of nitre, is deflagrated, pure carbonate of potassa remains mixed with charcoal, which by lixiviation, and the agency of quicklime, will afford a pure hydrate. Crystals of tartar calcined alone yield also a pure carbonate.

Caustic potassa, as I have said, after being fused in a silver crucible at a red heat, retains 1 prime equivalent of water. Hence its composition in 100 parts is, potassium 70, oxygen 14, water 16. Anhydrous potassa, or the oxyde free from water, can be obtained only by the combustion of potassium in the open air. It is composed of 83⅓ of metal, and 16⅔ of oxygen. Berzelius's numbers are, 83·05 and 16·95.

Caustic potassa may be crystallized; but in general it occurs as a white brittle substance of spec. grav. 1·708, which melts at a red heat, evaporates at a white heat, deliquesces into a liquid in the air, and attracts carbonic acid; is soluble in water and alcohol, forms soft soaps with fat oils, and soapy-looking compounds with resins and wax; dissolves sulphur, some metallic sulphurets, as those of antimony, arsenic, &c., as also silica, alumina, and certain other bases; and decomposes animal textures, as hair, wool, silk, horn, skin, &c. It should never be touched with the tongue or the fingers.

The following Table exhibits the quantity of *Fused Potassa* in 100 parts of *caustic ley*, at the respective densities :—

Sp. gr.	Pot. in 100.	Sp. gr.	Pot. in 100.	Sp. gr.	Pot. in 100.	Sp. gr.	Pot. in 100.	Sp. gr.	Pot.in100.
1·58	53·06	1·46	42·31	1·34	32·14	1·22	23·14	1·10	11·28
1.56	51·58	1·44	40·17	1·32	30·74	1·20	21·25	1·08	9·20
1·54	50·09	1·42	37·97	1·30	29·34	1·18	19·34	1·06	7·02
1·52	48·40	1·40	35·99	1·28	27·86	1·16	17·40	1·04	4·77
1·50	46·45	1·38	34·74	1·26	26·34	1·14	15·38	1·02	2·44
1·48	44·40	1·36	33·46	1·24	24·77	1·12	13·30	1·00	0·00

The only certain way of determining the quantity of free potassa in any solid or liquid, is from the quantity of a dilute acid of known strength which it can saturate.

The hydrate of potassa, or its ley, often contains a notable quantity of carbonate, the presence of which may be detected by lime water, and its amount be ascertained by the loss of weight which it suffers, when a weighed portion of the ley is poured into a weighed portion of dilute sulphuric acid poised in the scale of a balance.

There are two other oxydes of potassium; the suboxyde, which consists, according to Berzelius, of 90·74 of metal, and 9·26 oxygen; and the hyperoxyde, an orange-yellow substance, which gives off oxygen in the act of dissolving in water, and becomes potassa. It consists of 62 of metal, and 38 of oxygen.

Carbonate of potassa is composed of 48 parts of base, and 22 of acid, according to most British authorities; or, in 100 parts, of 68·57 and 31·43; but according to Berzelius, of 68·09 and 31·91.

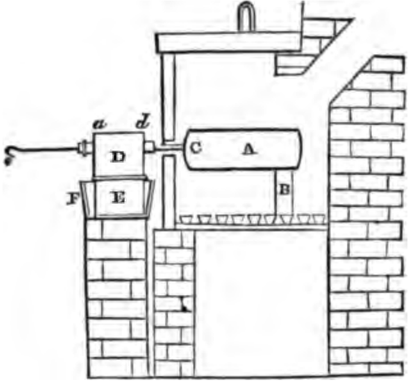
Carbonate of potassa, as it exists associated with carbon in calcined tartar, passes very readily into the *Bicarbonate*, on being moistened with water, and having a current of carbonic acid gas passed through it. The absorption takes place so rapidly, that the mass becomes hot, and therefore ought to be surrounded with cold water. The salt should then be dissolved in the smallest quantity of water at 120° F., filtered, and crystallized.

POTASSIUM (Eng. and Fr.; *Kalium*, Germ.) is a metal deeply interesting, not only from its own marvellous properties, but from its having been the first link in the chain of discovery which conducted Sir H. Davy through many of the formerly mysterious and untrodden labyrinths of chemistry.

The easiest and best mode of obtaining this elementary substance, is that contrived by Brunner, which I have often practised upon a considerable scale. Into the orifice of one of the iron bottles, as A, *fig.* 889, in which mercury is imported, adapt, by screwing, a piece of gun-barrel tube, 9 inches long; having brazed into its side, about 3 inches from its outer end, a similar piece of iron tube. Fill this retort two thirds with a mixture of 10 parts of cream of tartar, previously calcined in a covered crucible, and 1 of charcoal, both in powder; and lay it horizontally in an air-furnace, so that while the screw orifice is at the inside wall, the extremity of the straight or nozzle tube may project a few inches beyond the brickwork, and the tube brazed into it at right angles may descend pretty close to the outside wall, so as to dip its lower end a quarter of an inch beneath the surface of some rectified naptha contained in a copper bottle surrounded by ice-cold water. By bringing the condenser-vessel so near the furnace, the tubes along which the potassium vapor requires to pass, run less risk of getting obstructed. The horizontal straight end of the nozzle tube should be shut by screwing a stopcock air-tight into it. By opening the cock momentarily, and thrusting in a hot wire, this tube may be readily kept free, without permitting any considerable waste of potassium. The heat should be slowly applied at first, but eventually urged to whiteness, and continued as long as potassureted hydrogen continues to be disengaged. The retort, and the part of the nozzle tube exposed to the fire, should be covered with a good refractory lute, as described under the article PHOSPHORUS. The joints must be perfectly air-tight; and the vessel freed from every trace of mercury, by ignition, before it is charged with the tartar-ash.

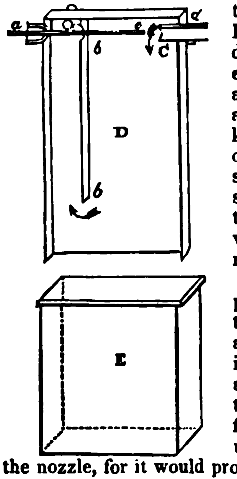
Tartar skilfully treated in this way will afford 3 per cent. of potassium; and when it is observed to send forth green fumes, it has commenced the production of the metal. Instead of the construction above described, the following form of apparatus may be employed.

889



A, *fig.* 889, represents the iron bottle, charged with the incinerated tartar; and B is a fire-brick support. A piece of fire-tile should also be placed between the bottom of the bottle and the back wall of the furnace, to keep the apparatus steady during the operation. Whenever the moisture is expelled, and the mass faintly ignited, the tube C should be screwed into the mouth of the bottle, through a small hole left for this purpose in the side of the furnace. That tube should be no longer, and the front wall of the furnace no thicker, than what is absolutely necessary. As soon as the reduction is indicated by the emission of green vapors, the receiver must be adapted, *d*, *a*, D, E, shown in a large scale in *fig.* 890.

890



This is a condenser, in two pieces, made of thin sheet copper; D, the upper part, is a rectangular box, open at bottom, about 10 inches high, by 5 or 6 long, and 2 wide; near to the side *a*, it is divided inside into two equal compartments, up to two thirds of its height, by a partition *b*, *b*, in order to make the vapors that issue from C pursue a downward and circuitous path. In each of its narrow sides, near the top, a short tube is soldered, at *d* and *a*; the former being fitted air-tight into the end of the nozzle of the retort, while the latter is closed with a cork traversed by a stiff iron probe *e*, which passes through a small hole in the partition *b*, *b*, under *c*, and is employed to keep the tube C clear, by its drill-shaped steel point. In one of the broad sides of the box D, near the top, a bit of pipe is soldered on at *c*, for receiving the end of a bent glass tube of safety, which dips its other and lower end into a glass containing naptha. E, the bottom copper box, with naptha, which receives pretty closely the upper case D, is to be immersed in a cistern of cold water containing some lumps of ice.

The chemical action by which potassa is reduced in this process seems to be somewhat complicated, and has not been thoroughly explained. A very small proportion of pure potassium is obtained; a great deal of it is converted into a black infusible mass, which passes over with the metal, and is very apt to block up the tube. Should this resist clearing out with the probe, the fire must be immediately withdrawn from the furnace, otherwise the apparatus will probably burst or blow up. Care must be taken to prevent any moisture getting into the nozzle, for it would probably produce a violent detonation.

When the operation has proceeded regularly, accompanied to the end with a constant evolution of gas, the retort becomes nearly empty, or contains merely a little charcoal, or carbonate of potassa, and the potassium collects in the naptha at the bottom of the receiver E, in the form of globules or rounded lumps, of greater or less size, and of a leaden hue. But the greater part of the metal escapes with the gas, in a state of combination not well understood. This gaseous compound burns with a white or reddish-white flame, and deposites potassa. Several ounces of potassium may be produced in this way at one operation; but, as thus obtained, it always contains some combined charcoal, which must be separated by distilling it in an iron retort, having its beak plunged in naptha.

Pure potassium, as procured in Sir H. Davy's original method, by acting upon fused potassa under a film of naptha, with the negative wire of a powerful voltaic battery, is very like quicksilver. It is semi-fluid at 60° Fahr., nearly liquid at 92°, and entirely so at 120°. At 50° it is malleable, and has the lustre of polished silver; at 32° it is brittle, with a crystalline fracture; and at a heat approaching to redness, it begins to boil, is volatilized, and converted into a green colored gas, which condenses into globules upon the surface of a cold body. Its specific gravity in the purest state is 0·865 at 60°. When heated in the air, it takes fire, and burns very vividly. It has a stronger affinity for oxygen than any other known substance; and is hence very difficult to preserve in the metallic state. At a high temperature it reduces almost every oxygenated body. When thrown upon water, it kindles, and moves about violently upon the surface, burning with a red flame till it be consumed; that is to say, converted into potassa. When thrown upon a cake of ice, it likewise kindles, and burns a hole in it. If a globule of it be laid upon wet turmeric paper, it takes fire, and runs about, marking its desultory path with red lines. The flame observed in these cases is owing chiefly to hydrogen, for it is at the expense of the water that the potassium burns.

Potassa, even in a pretty dilute solution, produces a precipitate with muriate of platinum, a phenomenon which distinguishes it from soda. It forms, moreover, with sulphuric and acetic acids, salts which crystallize very differently from the sulphates and acetates of soda.

POTTERY, PORCELAIN. (Eng. and Fr.; *Steingut*, *Porzellan*, Germ.) The French, who are fond of giving far-fetched names to the most ordinary things, have dignified the art of pottery with the title of *ceramique*, from the Greek noun *κεραμος*, an earthen pot, compounded of two words which signify, in that language, *burned clay*. In reference to chemical constitution, there are only two genera of baked stoneware. The first consists of a fusible earthy mixture, along with an infusible, which when combined are susceptible of becoming semi-vitrified and translucent in the kiln. This constitutes porcelain or china-ware; which is either hard and genuine, or tender and spurious, according to the quality and quantity of the fusible ingredient. The second kind consists of an infusible mixture of earths, which is refractory in the kiln, and continues opaque. This is pottery, properly so called; but it comprehends several subspecies, which graduate into each other by imperceptible shades of difference. To this head belong earthenware, stoneware, flintware, *fayence*, delftware, iron-stone china, &c.

The earliest attempts to make a compact stoneware, with a painted glaze, seem to have originated with the Arabians in Spain, about the 9th century, and to have passed thence into Majorca, in which island they were carried on with no little success. In the 14th century, these articles, and the art of imitating them, were highly prized by the Italians, under the name of Majolica, and *porcelana*, from the Portuguese word for a cup. The first fabric of stoneware possessed by them was erected at Fayenza, in the ecclesiastical state, whence the French term *fayence* is derived. The body of the ware was usually a red clay, and the glaze was opaque, being formed of the oxydes of lead and tin, along with potash and sand. Bernhard de Pallissy, about the middle of the 16th century, manufactured the first white *fayence*, at Saintes, in France; and not long afterwards the Dutch produced a similar article, of substantial make, under the name of delftware, and delft *porcelain*, but destitute of those graceful forms and paintings for which the ware of Fayenza was distinguished. Common fayence may be, therefore, regarded as a strong, well-burned, but rather coarse-grained kind of stoneware.

It was in the 17th century that a small work for making earthenware of a coarse description, coated with a common lead glaze, was formed at Burslem, in Staffordshire, which may be considered as the germ of the vast potteries now established in that county. The manufacture was improved about the year 1690, by two Dutchmen, the brothers Elers, who introduced the mode of glazing ware by the vapor of salt, which they threw by handfuls at a certain period among the ignited goods in the kiln. But these were rude, unscientific, and desultory efforts. It is to the late Josiah Wedgewood, Esq. that this country and the world at large are mainly indebted for the great modern advancement of the *ceramic* art. It was he who first erected magnificent factories, where every resource of mechanical and chemical science was made to co-operate with the arts of painting, sculpture, and statuary, in perfecting this valuable department of the industry of nations. So sound were his principles, so judicious his plans of procedure, and so ably have they been prosecuted by his successors in Staffordshire, that a population of 60,000 operatives now derives a comfortable subsistence within a district formerly bleak and barren, of 8 miles long by 6 broad, which contains 150 kilns, and is significantly called the Potteries.

OF THE MATERIALS OF POTTERY OR PORCELAIN, AND THEIR PREPARATION.

1. *Clay.*—The best clay from which the Staffordshire ware is made, comes from Dorsetshire; and a second quality from Devonshire; but both are well adapted for working, being refractory in the fire, and becoming very white when burnt. The clay is cleaned as much as possible by hand, and freed from loosely adhering stones at the

pits where it is dug. In the factory mounted by Mr. Wedgewood, which may be regarded as a type of excellence, the clay is cut to pieces, and then kneaded into a pulp with water, by engines; instead of being broken down with pickaxes, and worked with water by hand-paddles, in a square pit or water-tank, an old process, called *blunging*. The clay is now thrown into a cast-iron cylinder, 20 inches wide, and 4 feet high, or into a cone 2 feet wide at top, and 6 feet deep, in whose axis an upright shaft revolves, bearing knives as radii to the shaft. The knives are so arranged, that their flat sides lie in the plane of a spiral line; so that by the revolution of the shaft, they not only cut through everything in their way, but constantly press the soft contents of the cylinder or cone obliquely downwards, on the principle of a screw. Another set of knives stands out motionless at right angles from the inner surface of the cylinder, and projects nearly to the central shaft, having their edges looking opposite to the line of motion of the revolving blades. Thus the two sets of slicing implements, the one active, and the other passive, operate like shears in cutting the clay into small pieces, while the active blades, by their spiral form, force the clay in its comminuted state out at an aperture at the bottom of the cylinder or cone, whence it is conveyed into a cylindrical vat, to be worked into a pap with water. This cylinder is tub-shaped, being about 4 times wider than it is deep. A perpendicular shaft turns also in the axis of this vat, bearing cross spokes one below another, of which the vertical set on each side is connected by upright staves, giving the moveable arms the appearance of two or four opposite square paddle-boards revolving with the shaft. This wooden framework, or large blunger, as it is called, turns round amidst the water and clay lumps, so as to beat them into a fine pap, from which the stony and coarse sandy particles separate, and subside to the bottom. Whenever the pap has acquired a cream-consistenced uniformity, it is run off through a series of wire, lawn, and silk sieves, of different degrees of fineness, which are kept in continual agitation backwards and forward by a crank mechanism; and thus all the grosser parts are completely separated, and hindered from entering into the composition of the ware. This clay liquor is set aside in proper cisterns, and diluted with water to a standard density.

2. But clay alone cannot form a proper material for stoneware, on account of its great contractility by heat, and the consequent cracking and splitting in the kiln of the vessels made of it; for which reason, a silicious substance incapable of contraction must enter into the body of pottery. For this purpose, ground flints, called flint-powder by the potters, is universally preferred. The nodules of flint extracted from the chalk formation are washed, heated redhot in a kiln, like that for burning lime, and thrown in this state into water, by which treatment they lose their translucency, and become exceeding brittle. They are then reduced to a coarse powder in a stamping-mill, similar to that for stamping ores; see METALLURGY. The pieces of flint are laid on a strong grating, and pass through its meshes whenever they are reduced by the stamps to a certain state of comminution. This granular matter is now transferred to the proper flint-mill, which consists of a strong cylindrical wooden tub, bottomed with flat pieces of massive *chert*, or hornstone, over which are laid large flat blocks of similar chert, that are moved round over the others by strong iron or wooden arms projecting from an upright shaft made to revolve in the axis of the mill-tub. Sometimes the active blocks are fixed to these cross arms, and thus carried round over the passive blocks at the bottom. See *infrà*, under PORCELAIN, figures of the flint and feldspar mill. Into this cylindrical vessel a small stream of water constantly trickles, which facilitates the grinding motion and action of the stones, and works the flint powder and water into a species of pap. Near the surface of the water there is a plug-hole in the side of the tub, by which the creamy-looking flint liquor is run off from time to time, to be passed through lawn or silk sieves, similar to those used for the clay liquor; while the particles that remain on the sieves are returned into the mill. This pap is also reduced to a standard density by dilution with water; whence the weight of dry silicious earth present, may be deduced from the measure of the liquor.

The standard clay and flint liquors are now mixed together, in such proportion by measure, that the flint powder may bear to the dry clay the ratio of one to five, or occasionally one to six, according to the richness or plasticity of the clay; and the liquors are intimately incorporated in a revolving churn, similar to that employed for making the clay-pap. This mixture is next freed from its excess of water, by evaporation in oblong stone troughs, called *slip-kilns*, bottomed with fire-tiles, under which a furnace flue runs. The breadth of this evaporating trough varies from 2 to 6 feet; its length from 20 to 50; and its depth from 8 to 12 inches, or more.

By the dissipation of the water, and careful agitation of the pap, a uniform doughy mass is obtained; which, being taken out of the trough, is cut into cubical lumps. These are piled in heaps, and left in a damp cellar for a considerable time; that is, several months, in large manufactories. Here the dough suffers disintegration, promoted by a kind of fermentative action, due probably to some vegetable matter in the water and the clay; for it becomes black, and exhales a fetid odor. The argillaceous and silicious particles get disintegrated also by the action of the water, in such a way that the ware made with old paste is found to be more homogeneous, finer grained, and not so apt to crack or to get disfigured in the baking, as the ware made with newer paste.

But this chemical comminution must be aided by mechanical operations; the first of which is called the potter's *sloping or wedging*. It consists in seizing a mass of clay in the hands, and, with a twist of both at once, tearing it into two pieces, or cutting it with a wire. These are again slapped together with force, but in a different direction from that in which they adhered before, and then dashed down on a board. The mass is once more torn or cut asunder at right angles, again slapped together, and so worked repeatedly for 20 or 30 times, which ensures so complete an incorporation of the different parts, that if the mass had been at first half black and half white clay, it would now be of a uniform gray color. A similar effect is produced in some large establishments by a slicing machine, like that used for cutting down the clay lumps as they come from the pit.

In the axis of a cast iron cylinder or cone, an upright shaft is made to revolve, from which the spiral-shaped blades extend, with their edges placed in the direction of rotation. The pieces of clay subjected to the action of these knives (with the reaction of fixed ones) are minced to small morcels, which are forced pell-mell by the screw-like pressure into an opening of the bottom of the cylinder or cone, from which a horizontal pipe about 6 inches square proceeds. The dough is made to issue through this outlet, and is then cut into lengths of about 12 inches. These clay pillars or prisms are thrown back into the cylinder, and subjected to the same operation again and again, till the lumps have their particles perfectly blended together. This process may advantageously precede their being set aside to ripen in a damp cellar. In France the stoneware dough is not worked in such a machine; but after being beat with wooden mallets, a practice common also in England, it is laid down on a clean floor, and a workman is set to tread upon it with naked feet for a considerable time, walking in a spiral direction from the centre to the circumference, and from the circumference to the centre. In Sweden, and also in China (to judge from the Chinese paintings which represent their manner of making porcelain), the clay is trodden to a uniform mass by oxen. It is afterwards, in all cases, kneaded like baker's dough, by folding back the cake upon itself, and kneading it out, alternately.

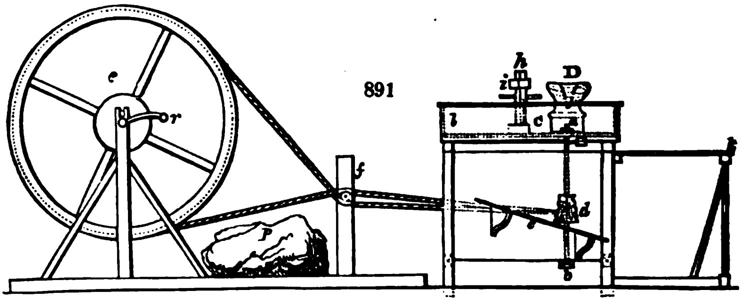
The process of *slapping* consists in cutting through a large mass with a wire, lifting up either half in both hands, and casting it down with great violence on the other; and this violent treatment of the clay is repeated till every appearance of air-bubbles is removed, for the smallest remaining vesicle expanding in the kiln, would be apt to cause blisters or warts upon the ware.

Having thus detailed the preparation of the stoneware paste, we have next to describe the methods of forming it into articles of various forms.

Throwing is performed upon a tool called the potter's lathe. (See fig., *infrà.*) This consists of an upright iron shaft, about the height of a common table, on the top of which is fixed, by its centre, a horizontal disc or circular piece of wood, of an area sufficiently great for the largest stoneware vessel to stand upon. The lower end of the shaft is pointed, and runs in a conical step, and its collar, a little below the top-board, being truly turned, is embraced in a socket attached to the wooden frame of the lathe. The shaft has a pulley fixed upon it, with grooves for 3 speeds, over which an endless band passes from a fly-wheel, by whose revolution any desired rapidity of rotation may be given to the shaft and its top-board. This wheel, when small, may be placed alongside, as in the turner's lathe, and then it is driven by a treadle and crank; or when of larger dimensions, it is turned by the arms of a laborer. Sometimes, indeed, the wooden plate is replaced by a large thick disc of Paris plaster, which is whirled round by the hand of the potter, without the intervention of a pulley and fly-wheel, and affords sufficient centrifugal power for fashioning small vessels. The mass of dough to be thrown, is weighed out or gauged by an experienced hand. The thrower dashes down the lump on the centre of the revolving board, and dipping his hands frequently in an adjoining tub of water, he works up the clay into a tall irregular cylinder, and then down into a cake, alternately, till he has secured the final extrication of air-bubbles, and then gives the proper form to the vessel under a less speed of rotation, regulating its dimensions by wooden pegs and gauges. He now cuts it off at the base with a piece of fine brass wire, fastened to a handle at either end. The vessel thus rudely fashioned is placed in a situation where it may dry gradually to a proper point. At a certain stage of the drying, called the *green state*, it possesses a greater tenacity than at any other, till it is baked. It is then taken to another lathe, called the turning lathe, where it is attached by a little moisture to the vertical face of a wooden chuck, and turned nicely into its proper shape with a very sharp tool, which also smooths it. After this it is slightly burnished with a smooth steel surface.

DESCRIPTION OF THE POTTER'S LATHE.

A, *fig.* 891, is the profile of the English potter's lathe, for blocking out round ware; c is the table or tray; *a* is the head of the lathe, with its horizontal disc; *a*, *b*, is the upright shaft of the head; *d*, pulleys with several grooves of different diameters, fixed upon the shaft, for receiving the driving-cord or band; *k* is a bench upon which the workman sits astride; *e*, the treadle foot-board; *l* is a ledge-board,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for catching the shavings of clay which fly off from the lathe; *h* is an instrument, with a slide-nut *i*, for measuring the objects in the blocking out; *c* is the fly-wheel with its winch-handle *r*, turned by an assistant; the sole-frame is secured in its place by the heavy stone *p*; *f* is the oblong guide-pulley, having also several grooves for converting the vertical movement of the fly-wheel into the horizontal movement of the head of the lathe.

D is one of the intermediate forms given by the potter to the ball of clay, as it revolves upon the head of the lathe.

In large potteries, the whole of the lathes, both for throwing and turning, are put in motion by a steam-engine. The vertical spindle of the lathe has a bevel wheel on it, which works in another bevel toothed wheel fixed to a horizontal shaft. This shaft is provided with a long conical wooden drum, from which a strap ascends to a similar conical drum on the main lying shaft. The apex of the one cone corresponds to the base of the other, which allows the strap to retain the same degree of tension (see the conical drum apparatus of the *Stearine-press*), while it is made to traverse horizontally, in order to vary the speed of the lathe at pleasure. When the belt is at the base of the driving-cone, it works near the vertex of the driven one, so as to give a maximum velocity to the lathe, and *vice versâ.*

During the throwing of any article, a separate mechanism is conducted by a boy, which makes the strap move parallel to itself along these conical drums, and nicely regulates the speed of the lathe. When the strap runs at the middle of the cones, the velocity of each shaft is equal. By this elegant contrivance of parallel cones reversed, the velocity rises gradually to its maximum, and returns to its minimum or slower motion when the workman is about finishing the article thrown. The strap is then transferred to a pair of loose pulleys, and the lathe stops. The vessel is now cut off at the base with small wire; is dried, turned on a power lathe, and polished as above described.

The same degree of dryness which admits of the clay being turned on the lathe, also suits for fixing on the handles and other appendages to the vessels. The parts to be attached, being previously prepared, are joined to the circular work by means of a thin paste which the workmen call *slip*, and the seams are then smoothed off with a wet sponge. They are now taken to a stove-room heated to 80° or 90° F., and fitted up with a great many shelves. When they are fully dried, they are smoothed over with a small bundle of hemp, if the articles be fine, and are then ready for the kiln, which is to convert the tender clay into the hard *biscuit.*

A great variety of pottery wares, however, cannot be fashioned on the lathe, as they are not of a circular form. These are made by two different methods, the one called *press-work*, and the other *casting*. The press-work is done in moulds made of Paris plaster, the one half of the pattern being formed in the one side of the mould, and the other half in the other side: these moulding-pieces fit accurately together. All vessels of an oval form, and such as have flat sides, are made in this way. Handles of teapots, and fluted solid rods of various shapes, are formed by pressure also; viz., by squeezing the dough contained in a pump-barrel through different shaped orifices at its bottom, by working a screw applied to the piston-rod. The worm-shaped dough, as it issues, is cut to proper lengths, and bent into the desired form. Tubes may be also made on the same pressure principle, only a tubular opening must be provided in the bottom plate of the clay-forcing pump.

The other method of fashioning earthenware articles is called *casting*, and is, perhaps, the most elegant for such as have an irregular shape. This operation consists in pouring the clay, in the state of pap or slip, into plaster moulds, which are kept in a desiccated state. These moulds, as well as the pressure ones, are made in halves, which nicely correspond together. The slip is poured in till the cavity is quite full, and is left in the mould for a certain time, more or less, according to the intended thickness of the vessel. The absorbent power of the plaster soon abstracts the water, and makes the coat of clay in contact with it quite doughy and stiff, so that the part still liquid being poured out, a hollow shape remains, which when removed from the mould constitutes the half of the vessel, bearing externally the exact impress of the mould. The thickness of the clay varies with the time that the paste has stood upon the plaster. These *cast* articles are dried to the green state, like the preceding, and then joined accurately with *slip*. Imitations of flowers and foliage are elegantly executed in this way. This operation, which is called *furnishing*, requires very delicate and dexterous manipulation.

The saggers for the unglazed colored stoneware should be covered inside with a glaze composed of 12 parts of common salt and 30 of potash, or 6 parts of potash and 14 of salt; which may be mixed with a little of the common enamel for the glazed pottery saggers. The bottom of each sagger has some bits of flints sprinkled upon it, which become so adherent after the first firing as to form a multitude of little prominences for setting the ware upon, when this does not consist of plates. It is the duty of the workmen belonging to the glaze kiln to make the saggers during the intervals of their work; or, if there be a relay of hands, the man who is not firing makes the saggers.

The English kilns differ from those of France and Germany, in their construction, in the nature of their fuel, and in the high temperature required to produce a surface sufficiently hard for a perfectly fine glaze.

When the ware is sufficiently dry, and in sufficient quantity to fill a kiln, the next process is placing the various articles in the baked fire-clay vessels, which may be either of a cylindrical or oval shape; called *gazettes*, Fr.; *kapseln*, Germ. These are from 6 to 8 inches deep, and from 12 to 18 inches in diameter. When packed full of the dry ware, they are piled over each other in the kiln. The bottom of the upper sagger forms the lid of its fellow below; and the junction of the two is luted with a ring of soft clay applied between them. These dishes protect the ware from being suddenly and unequally heated, and from being soiled by the smoke and vapors of the fuel. Each pile of saggers is called a *bung*.

POTTERY KILN OF STAFFORDSHIRE.

Figs. 892, 893, 894, 895, 896, represent the kiln for baking the biscuit, and also for running the glaze, in the English potteries.

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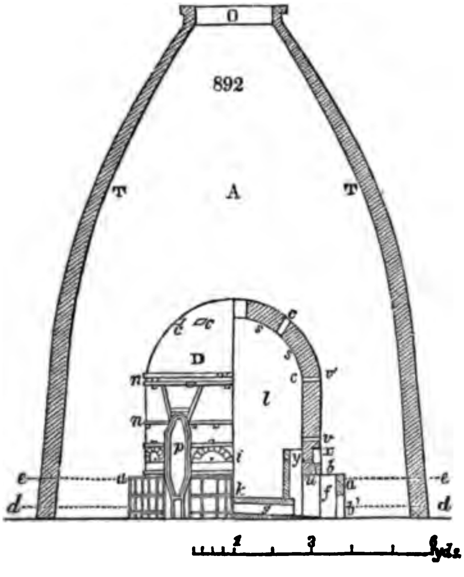

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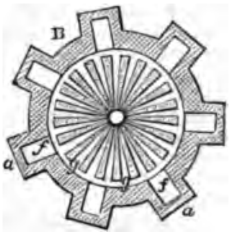

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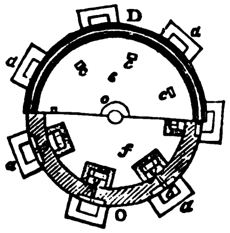


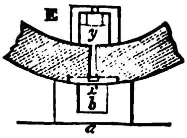
a, *a*, *figs*. 892, 893, and 894, are the furnaces which heat the kiln; of which *b*, in *fig*. 892, are the upper mouths, and *b′* the lower; the former being closed more or less by the fire-tile *z*, shown in *fig*. 896.

f is one fireplace; for the manner of distributing the fuel in it, see *fig*. 896.

g, *y*, *figs*. 892 and 896, are the horizontal and vertical flues and chimneys for conducting the flame and smoke. *l* is the laboratory, or body of the kiln; having its floor *k* sloping slightly downwards from the centre to the circumference. *x*, *y*, is the slit of the horizontal register, leading to the chimney flue *y* of the furnace, being the first regulator; *x*, *u*, is the vertical register conduit, leading to the furnace or mouth *f*, being the second regulator; *v* is the register slit above the furnace, and its vertical flue leading into the body of the kiln; *v′*, *c*, slit for regulating flue at the shoulder of the kiln; *i* is an arch which supports the walls of the kiln, when the furnace is under repair; c, c, are small flues in the vault *s* of the laboratory. *h*, *fig*. 893, is the central flue, called *lunette*, of the laboratory.

T, T, is the conical tower or *howell*, strengthened with a series of iron hoops. o′ is the great chimney or *lunette* of the tower; *p* is the door of the laboratory, bound inside with an iron frame.

895



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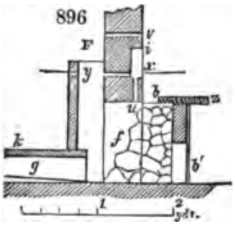

A, is the complete kiln and *howell*, with all its appurtenances.

B, *fig*. 893, is the plan at the level *d*, *d*, of the floor, to show the arrangement and distribution of all the horizontal flues, both circular and radiating.

C, *fig*. 894, is a plan at the level *e*, *e*, of the upper mouths *b*, of the furnaces, to show the disposition of the fireplaces of the vertical flues, and of the horizontal registers, or peep-holes.

D, *fig*. 894, is a bird's-eye view of the top of the vault or dome *s*, to show the disposition of the vent-holes *c*, *c*.

E, *fig*. 895, is a detailed plan at the level *c*, *c*, of one furnace and its dependencies.

F, *fig*. 896, is a transverse section, in detail, of one furnace and its dependencies.

The same letters in all the figures indicate the same objects.

Charging of the kiln.—The saggers are piled up first in the space between each of the upright furnaces, till they rise to the top of the flues. These contain the smaller articles. Above this level, large fire tiles are laid, for supporting other saggers, filled with teacups, sugar-basins, &c. In the bottom part of the pile, within the preceding, the same sorts of articles are put; but in the upper part all such articles are placed as require a high heat. Four piles of small saggers, with a middle one 10 inches in height, complete the charge. As there are 6 piles between each furnace, and as the biscuit kiln has 8 furnaces, a charge consequently amounts to 48 or 50 *bungs*, each composed of from 18 to 19 saggers. The inclination of the bungs ought always to follow the form of the kiln, and should therefore tend towards the centre, lest the strong draught of the furnaces should make the saggers fall against the walls of the kiln, an accident apt to happen were these piles perpendicular. The last sagger of each bung is covered with an unbaked one, three inches deep, in place of a round lid. The watches are small cups, of the same biscuit as the charge, placed in saggers, four in number, above the level of the flue-tops. They are taken hastily out of the saggers, lest they should get smoked, and are thrown into cold water.

When the charging is completed, the firing is commenced, with coal of the best quality. The management of the furnace is a matter of great consequence to the success of the process. No greater heat should be employed for some time than may be necessary to agglutinate the particles which enter into the composition of the paste, by evaporating all the humidity; and the heat should never be raised so high as to endanger the fusion of the ware, which would make it very brittle.

Whenever the mouth or door of the kiln is built up, a child prepares several fires in the neighborhood of the *howell*, while a laborer transports in a wheelbarrow a supply of coals, and introduces into each furnace a number of lumps. These lumps divide the furnace into two parts; those for the upper flues being placed above, and those for the ground flues below, which must be kept unobstructed.

The fire-mouths being charged, they are kindled to begin the baking, the regulator tile *z*, *fig*. 896, being now opened; an hour afterwards the bricks at the bottom of the furnace are stopped up. The fire is usually kindled at 6 o'clock in the evening, and progressively increased till 10, when it begins to gain force, and the flame rises half-way up the chimney. The second charge is put in at 8 o'clock, and the mouths of the furnaces are then covered with tiles; by which time the flame issues through the vent of the tower. An hour afterwards a fresh charge is made; the tiles *z*, which cover the furnaces, are slipped back; the cinders are drawn to the front, and replaced with small coal. About half past 11 o'clock the kiln-man examines his furnaces, to see that their draught is properly regulated. An hour afterwards a new charge of coal is applied; a practice repeated hourly till 6 o'clock in the morning. At this moment he takes out his first *watch*, to see how the baking goes on. It should be at a very pale-red heat; but the watch of 7 o'clock should be a deeper red. He removes the tiles from those furnaces which appear to have been burning too strongly, or whose flame issues by the orifices made in the shoulder of the kiln; and puts tiles upon those which are not hot enough. The flames glide along briskly in a regular manner. At this period he draws out the watches every quarter of an hour, and compares them with those reserved from a previous standard kiln: and if he observes a similarity of appearance, he allows the furnaces to burn a little longer; then opens the mouths carefully and by slow degrees; so as to lower the heat, and finish the round.

The baking usually lasts from 40 to 42 hours; in which time the biscuit kiln may consume 14 tons of coals; of which four are put in the first day, seven the next day and following night, and the four last give the strong finishing heat.

Emptying the kiln.—The kiln is allowed to cool very slowly. On taking the ware out of the saggers, the biscuit is not subjected to friction, as in the foreign potteries, because it is smooth enough; but is immediately transported to the place where it is to be dipped in the glaze or enamel tub. A child makes the pieces ring, by striking with the handle of the brush, as he dusts them, and then immerses them into the glaze cream; from which tub they are taken out by the enameller, and shaken in the air. The tub usually contains no more than 4 or 5 inches depth of the glaze, to enable the workman to pick out the articles more readily, and to lay them upon a board, whence they are taken by a child to the glaze kiln.

Glazing.—A good enamel is an essential element of fine stoneware; it should experience the same dilatation and contraction by heat and cold as the biscuit which it covers. The English enamels contain nothing prejudicial to health, as many of the foreign glazes do; no more lead being added to the former than is absolutely necessary to convert the silicious and aluminous matters with which it is mixed into a perfectly neutral glass.

Three kinds of glazes are used in Staffordshire; one for the common pipe-clay or cream-colored ware; another for the finer pipe-clay ware to receive impressions, called *printing body;* a third for the ware which is to be ornamented by painting with the pencil.

The glaze of the first or common ware is composed of 53 parts of white lead, 16 of Cornish stone, 36 of ground flints, and 4 of flint glass; or of 40 of white lead, 36 of Cornish stone, 12 of flints, and 4 of flint or crystal glass. These compositions are not fritted; but are employed after being simply triturated with water into a thin paste.

The following is the composition of the glaze intended to cover all kinds of figures printed in metallic colors; 26 parts of white feldspar are fritted with 6 parts of soda, 2 of nitre, and 1 of borax; to 20 pounds of this frit, 26 parts of feldspar, 20 of white lead, 6 of ground flints, 4 of chalk, 1 of oxyde of tin, and a small quantity of oxyde of cobalt, to take off the brown cast, and give a faint azure tint, are added.

The following recipe may also be used. Frit together 20 parts of flint glass, 6 of flints, 2 of nitre, and 1 of borax; add to 12 parts of that frit, 40 parts of white lead, 36 of feld spar, 8 of flints, and 6 of flint glass; then grind the whole together into a uniform cream-consistenced paste.

As to the stoneware which is to be painted, it is covered with a glaze composed of 13 parts of the printing-color frit, to which are added 50 parts of red lead, 40 of white lead, and 12 of flint; the whole having been ground together.

The above compositions produce a very hard glaze, which cannot be scratched by the knife, is not acted upon by vegetable acids, and does no injury to potable or edible articles kept in the vessels covered with it. It preserves for an indefinite time the glassy lustre, and is not subject to crack and exfoliate, like most of the Continental stoneware, made from common pipe-clay.

In order that the saggers in which the articles are baked, after receiving the glaze, may not absorb some of the vitrifying matter, they are themselves coated, as above mentioned, with a glaze composed of 13 parts of common salt, and 30 parts of potash, simply dissolved in water, and brushed over them.

Glaze kiln.—This is usually smaller than the biscuit kiln, and contains no more than 40 or 45 bungs or columns, each composed of 16 or 17 saggers. Those of the first bung rest upon round tiles, and are well luted together with a finely ground fire-clay of only moderate cohesion; those of the second bung are supported by an additional tile. The lower saggers contain the cream-colored articles, in which the glaze is softer than that which covers the blue printed ware; this being always placed in the intervals between the furnaces, and in the uppermost saggers of the columns. The bottom of the kiln, where the glazed ware is not baked, is occupied by printed biscuit ware.

Pyrometric balls of red clay, coated with a very fusible lead enamel, are employed in the English potteries to ascertain the temperature of the glaze kilns. This enamel is so rich, and the clay upon which it is spread is so fine-grained and compact, that even when exposed for three hours to the briskest flame, it does not lose its lustre. The color of the clay alone changes, whereby the workman is enabled to judge of the degree of heat within the kiln. At first the balls have a pale red appearance; but they become browner with the increase of the temperature. The balls, when of a slightly dark-red color, indicate the degree of baking for the hard glaze of pipe-clay ware; but if they become dark brown, the glaze will be much too hard, being that suited for *ironstone* ware; lastly, when they acquire an almost black hue, they show a degree of heat suited to the formation of a glaze upon porcelain.

The *glazier* provides himself at each round with a stock of these ball *watches*, reserved from the preceding baking, to serve as objects of comparison; and he never slackens the firing till he has obtained the same depth of shade, or even somewhat more; for it may be remarked, that the more rounds a glaze kiln has made, the browner the balls are apt to become. A new kiln bakes a round of enamel-ware sooner than an old one; as also with less fuel, and at a lower temperature. The watch-balls of these first rounds have generally not so deep a color as if they were tried in a furnace three or four months old. After this period, cracks begin to appear in the furnaces; the horizontal flues get partially obstructed, the joinings of the brickwork become loose; in consequence of which there is a loss of heat and waste of fuel; the baking of the glaze takes a longer time, and the pyrometric balls assume a different shade from what they had on being taken out of the new kiln, so that the first watches are of no comparable use after two months. The baking of enamel is commenced at a low temperature, and the heat is progressively increased; when it reaches the melting point of the glaze, it must be maintained steadily, and the furnace mouths be carefully looked after, lest the heat should be suffered to fall. The firing is continued 14 hours, and then gradually lowered by slight additions of fuel; after which the kiln is allowed from 5 to 6 hours to cool.

Muffles.—The paintings and the printed figures applied to the glaze of stoneware and porcelain are baked in muffles of a peculiar form. *Fig.* 897 is a lateral elevation of one of these muffles; *fig.* 898 is a front view. The same letters denote the same parts in the two figures.

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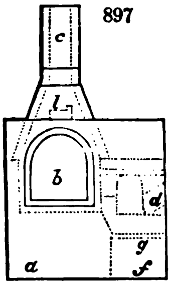

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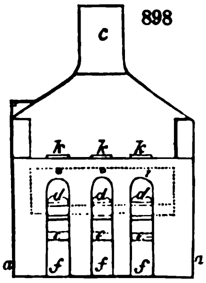


a is the furnace; *b*, the oblong muffle, made of fire-clay, surmounted with a dome pierced with three apertures *k*, *k*, *k*, for the escape of the vaporous matters of the colors and volatile oils with which they are ground up; *c* is the chimney; *d*, *d*, feed-holes, by which the fuel is introduced; *e*, the fire-grate; *f*, the ash-pit; channels are left in the bottom of the furnace to facilitate the passage of the flame beneath the muffle; *g* is a lateral hole, which makes a communication across the furnace in the muffle, enabling the kiln man to ascertain what is passing within; *k*, *k*, are the lateral chinks for observing the progress of the firing or flame; *l*, is an opening scooped out in the front of the chimney to modify its draught.

The articles which are printed or painted upon the glaze are placed in the muffle without saggers, upon tripods, or moveable supports furnished with feet. The muffle being charged, its mouth is closed with a fire-tile well luted round its edges. The fuel is then kindled in the fire-places *d*, *d*, and the door of the furnace is closed with bricks, in which a small opening is left for taking out samples, and for examining the interior of the muffle. These sample or trial pieces, attached to a strong iron wire, show the progress of the baking operation. The front of the fireplaces is covered with a sheet-iron plate, which slides to one side, and may be shut whenever the kiln is charged. Soon after the fire is lighted, the flame, which communicates laterally from one furnace to another, envelopes the muffle on all sides, and thence rises up the chimney.

Printing of stoneware.—The printing under the stoneware glaze is generally performed by means of cobalt, and has different shades of blue according to the quantity of coloring matter employed. After having subjected this oxyde to the processes requisite for its purification, it is mixed with a certain quantity of ground flints and sulphate of baryta, proportioned to the dilution of the shade. These materials are fritted and ground; but before they are used, they must be mixed with a flux consisting of equal parts by weight of flint glass and ground flints, which serves to fix the color upon the biscuit, so that the immersion in the glaze liquor may not displace the lines printed on, as also to aid in fluxing the cobalt.

The following are the processes usually practised in Staffordshire for printing under the glaze.

The cobalt, or whatever color is employed, should be ground upon a porphyry slab, with a varnish prepared as follows:—A pint of linseed oil is to be boiled to the consistence of thick honey, along with 4 ounces of rosin, half a pound of tar, and half a pint of oil of amber. This is very tenacious, and can be used only when liquefied by heat; which the printer effects by spreading it upon a hot cast-iron plate.

The printing plates are made of copper, engraved with pretty deep lines in the common way. The printer, with a leather muller, spreads upon the engraved plate, previously heated, his color, mixed up with the above oil varnish, and removes what is superfluous with a pallet knife; then cleans the plate with a dossil filled with bran, tapping and wiping as if he were removing dust from it. This operation being finished, he takes the paper intended to receive the impression, soaks it with soap-water, and lays it moist upon the copper-plate. The soap makes the paper part more readily from the copper, and the thick ink part more readily from the biscuit. The copper-plate is now passed through the engraver's cylinder press, the proof leaf is lifted off and handed to the women, who cut it into detached pieces, which they apply to the surface of the biscuit. The paper best fitted for this purpose is made entirely of linen rags; it is very thin, of a yellow color, and unsized, like tissue blotting-paper.

The stoneware biscuit never receives any preparation before being imprinted, the oil of the color being of such a nature as to fix the figures firmly. The printed paper is pressed and rubbed on with a roll of flannel, about an inch and a half in diameter, and 12 or 15 inches long, bound round with twine, like a roll of tobacco. This is used as a burnisher, one end of it being rested against the shoulder, and the other end being rubbed upon the paper; by which means it transfers all the engraved traces to the biscuit. The piece of biscuit is laid aside for a little, in order that the color may take fast hold; it is then plunged into water, and the paper is washed away with a sponge.

When the paper is detached, the piece of ware is dipped into a caustic alkaline ley to saponify the oil, after which it is immersed in the glaze liquor, with which the printed figures readily adhere. This process, which is easy to execute, and very economical, is much preferable to the old plan of passing the biscuit into the muffle after it had been printed, for the purpose of fixing and volatilizing the oils. When the paper impression is applied to pieces of porcelain, they are heated before being dipped in the water, because, being already semi-vitrified, the paper sticks more closely to them than to the biscuit, and can be removed only by a hard brush.

The impression above the glaze is done by quite a different process, which dispenses with the use of the press. A quantity of fine clean glue is melted and poured hot upon a large flat dish, so as to form a layer about a quarter of an inch thick, and of the consistence of jelly. When cold it is divided into cakes of the size of the copper-plates it is intended to cover.

The operative (a woman) rubs the engraved copper-plate gently over with linseed oil boiled thick, immediately after which she applies the cake of glue, which she presses down with a silk dossil filled with bran. The cake licks up all the oil out of the engraved lines; it is then cautiously lifted off, and transferred to the surface of the glazed ware which it is intended to print. The glue cake being removed, the enamel surface must be rubbed with a little cotton, whereby the metallic colors are attached only on the lines charged with oil: the piece is then heated under the muffle. The same cake of glue may serve for several impressions.

Ornaments and coloring.—Common stoneware is colored by means of two kinds of apparatus; the one called the blowing-pot, the other the worming-pot. The ornaments made in relief in France, are made hollow (intaglio) in England, by means of a mould engraved in relief, which is passed over the article. The impression which it produces is filled with a thick clay paste, which the workman throws on with the blowing-pot. This is a vessel like a tea-pot, having a spout, but it is hermetically sealed at top with a clay plug, after being filled with the pasty liquor. The workman, by blowing in at the spout, causes the liquor to fly out through a quill pipe which goes down through the clay plug into the liquor. The jet is made to play upon the piece while it is being turned upon the lathe; so that the hollows previously made in it by the mould or stamp are filled with a paste of a color different from that of the body. When the piece has acquired sufficient firmness to bear working, the excess of the paste is removed by an instrument called a *tournasin*, till the ornamental figure produced by the stamp be laid bare; in which case merely the color appears at the bottom of the impression. By passing in this manner several layers of clay liquor of different colors over each other with the blowing-pot, net-work, and decorations of different colors and shades, are very rapidly produced.

The serpentine or snake pots, established on the same principle, are made of tin plate in three compartments, each containing a different color. These open at the top of the vessel in a common orifice, terminated by small quill tubes. On inclining the vessel, the three colors flow out at once in the same proportion at the one orifice, and are let fall upon the piece while it is being slowly turned upon the lathe; whereby curious serpent-like ornaments may be readily obtained. The clay liquor ought to be in keeping with the stoneware paste. The blues succeed best when the ornaments are made with the finer pottery mixtures given above.

Metallic lustres applied to stoneware.—The metallic lustre being applied only to the outer surface of vessels, can have no bad effect on health, whatever substances be employed for the purpose; and as the glaze intended to receive it is sufficiently fusible, from the quantity of lead it contains, there is no need of adding a flux to the metallic coating. The glaze is in this case composed of 60 parts of litharge, 36 of feldspar, and 15 of flints.

The silver and platina lustres are usually laid upon a white ground, while those of gold and copper, on account of their transparency, succeed only upon a colored ground. The dark-colored stoneware is, however, preferable, as it shows off the colors to most advantage; and thus the shades may be varied by varying the colors of the ornamental figures applied by the blowing-pot.

The gold and platina lustre is almost always applied to a paste body made on purpose, and coated with the above-described lead glaze. This paste is brown, and consists of 4 parts of clay, 4 parts of flints, an equal quantity of kaolin (china clay), and 6 parts of feldspar. To make brown figures in relief upon a body of white paste, a liquor is mixed up with this paste, which ought to weigh 26 ounces per-pint, in order to unite well with the other paste, and not to exfoliate after it is baked.

Preparation of gold lustre.—Dissolve first in the cold, and then with heat, 48 grains of fine gold in 288 grains of an aqua regia, composed of 1 ounce of nitric acid and 3 ounces of muriatic acid; add to that solution 4½ grains of grain tin, bit by bit; and then pour some of that compound solution into 20 grains of balsam of sulphur diluted with 10 grains of oil of turpentine. The balsam of sulphur is prepared by heating a pint of linseed oil, and 2 ounces of flowers of sulphur, stirring them continually till the mixture begins to boil; it is then cooled, by setting the vessel in cold water; after which it is stirred afresh, and strained through linen. The above ingredients, after being well mixed, are to be allowed to settle for a few minutes; then the remainder of the solution of gold is to be poured in, and the whole is to be triturated till the mass has assumed such a consistence that the pestle will stand upright in it; lastly, there must be added to the mixture 30 grains of oil of turpentine, which being ground in, the gold lustre is ready to be applied. If the lustre is too light or pale, more gold must be added, and if it have not a sufficiently violet or purple tint, more tin must be used.

Platina lustre.—Of this there are two kinds; one similar to polished steel, another lighter and of a silver-white hue. To give stoneware the steel color with platina, this metal must be dissolved in an aqua regia composed of 2 parts of muriatic acid, and 1 part of nitric. The solution being cooled, and poured into a capsule, there must be added to it, drop by drop, with continual stirring with a glass rod, a *spirit of tar*, composed of equal parts of tar and sulphur boiled in linseed oil and filtered. If the platina solution be too strong, more spirit of tar must be added to it; but if too weak, it must be concentrated by boiling. Thus being brought to the proper pitch, the mixture may be spread over the piece, which being put into the muffle, will take the aspect of steel.

The oxyde of platina, by means of which the silver lustre is given to stoneware, is prepared as follows:—After having dissolved to saturation the metal in an aqua regia composed of equal parts of nitric and muriatic acid, the solution is to be poured into a quantity of boiling water. At the same time a capsule, containing solution of sal-ammoniac, is placed upon a sand-bath, and the platina solution being poured into it, the metal will fall down in the form of the well-known yellow precipitate, which is to be washed with cold water till it is perfectly edulcorated, then dried, and put up for use.

This metallic lustre is applied very smoothly by means of a flat camel's hair brush. It is then to be passed through the muffle kiln; but it requires a second application of the platinum to have a sufficient body of lustre. The articles sometimes come black out of the kiln, but they get their proper appearance by being rubbed with cotton.

Platina and *gold lustre;* by other recipes.

Platina lustre.—Dissolve 1 ounce of platinum in aqua regia formed of 2 parts of muriatic acid and 1 part of nitric acid, with heat upon a sand-bath, till the liquid is reduced to two thirds of its volume; let it cool; decant into a clean vessel, and pour into it, drop by drop, with constant stirring, some distilled tar, until such a mixture is produced as will give a good result in a trial upon the ware in the kiln. If the lustre be too intense, more tar must be added; if it be too weak, the mixture must be concentrated by further evaporation.

Gold lustre.—Dissolve four shillings' worth of gold in aqua regia with a gentle heat.

To the solution, when cool, add 2 grains of grain tin, which will immediately dissolve. Prepare a mixture of half an ounce of balsam of sulphur with a little essence of turpentine, beating them together till they assume the appearance of milk. Pour this mixture into the solution of gold and tin, drop by drop, with continual stirring; and place the whole in a warm situation for some time.

It is absolutely necessary to apply this lustre only upon an enamel or glaze which has already passed through the fire, otherwise the sulphur would tarnish the composition.

These lustres are applied with most advantage upon chocolate and other dark grounds. Much skill is required in their firing, and a perfect acquaintance with the quality of the glaze on which they are applied.

An iron lustre is obtained by dissolving a bit of steel or iron in muriatic acid, mixing this solution with the spirit of tar, and applying it to the surface of the ware.

Aventurine glaze.—Mix a certain quantity of silver leaf with the above-described soft glaze, grind the mixture along with some honey and boiling water, till the metal assume the appearance of fine particles of sand. The glaze, being naturally of a yellowish hue, gives a golden tint to the small fragments of silver disseminated through it. Molybdena may also be applied to produce the aventurine aspect.

The granite-like gold lustre is produced by throwing lightly with a brush a few drops of oil of turpentine upon the goods already covered with the preparation for gold lustre. These cause it to separate and appear in particles resembling the surface of granite. When marbling is to be given to stoneware, the lustres of gold, platina, and iron are used at once, which blending in the fusion, form veins like those of marble.

Pottery and stoneware of the Wedgewood color.—This is a kind of semi-vitrified ware, called *dry bodies*, which is not susceptible of receiving a superficial glaze. This pottery is composed in two ways: the first is with barytic earths, which act as fluxes upon the clays, and form enamels: thus the Wedgewood *jasper* ware is made.

The white vitrifying pastes, fit for receiving all sorts of metallic colors, are composed of 47 parts of sulphate of barytes, 15 of feldspar, 26 of Devonshire clay, 6 of sulphate of lime, 15 of flints, and 10 of sulphate of strontites. This composition is capable of receiving the tints of the metallic oxydes and of the ochrous metallic earths. Manganese produces the dark purple color; gold precipitated by tin, a rose color; antimony, orange; cobalt, different shades of blue; copper is employed for the browns and the dead-leaf greens; nickel gives, with potash, greenish colors.

One per cent. of oxyde of cobalt is added; but one half, or even one quarter, of a per cent. would be sufficient to produce the fine Wedgewood blue, when the nickel and manganese constitute 3 per cent., as well as the carbonate of iron. For the blacks of this kind, some English manufacturers mix black oxyde of manganese with the black oxyde of iron, or with ochre. Nickel and umber afford a fine brown. Carbonate of iron, mixed with bole or *terra di Sienna*, gives a beautiful tint to the paste; as also manganese with cobalt, or cobalt with nickel. Antimony produces a very fine color when combined with the carbonate of iron in the proportion of 2 per cent., along with the ingredients necessary to form the above-described vitrifying paste.

The following is another vitrifying paste, of a much softer nature than the preceding. Feldspar, 30 parts; sulphate of lime, 23; silex, 17; potter's clay, 15; kaolin of Cornwall (china clay), 15; sulphate of baryta, 10.

These vitrifying pastes are very plastic, and may be worked with as much facility as English pipe-clay. The round ware is usually turned upon the lathe. It may, however, be moulded, as the oval pieces always are. The more delicate ornaments are cast in hollow moulds of baked clay, by women and children, and applied with remarkable dexterity upon the turned and moulded articles. The colored pastes have such an affinity for each other, that the detached ornaments may be applied not only with a little gum water upon the convex and concave forms, but they may be made to adhere without experiencing the least cracking or chinks. The colored pastes receive only one fire, unless the inner surface is to be glazed; but a gloss is given to the outer surface. The enamel for the interior of the black Wedgewood ware is composed of 6 parts of red lead, 1 of silex, and 2 ounces of manganese, when the mixture is made in pounds' weight.

The operation called *smearing*, consists in giving an external lustre to the unglazed semi-vitrified ware. The articles do not in this way receive any immersion, nor even the aid of the brush or pencil of the artist; but they require a second fire. The saggers are coated with the salt glaze already described. These cases, or saggers, communicate by reverberation the lustre so remarkable on the surface of the English stoneware; which one might suppose to be the result of the glaze tub, or of the brush. Occasionally also a very fusible composition is thrown upon the inner surface of the muffle, and 5 or 6 pieces called *refractories* are set in the middle of it, coated with the same composition. The intensity of the heat converts the flux into vapor; a part of this is condensed upon the surfaces of the contiguous articles; so as to give them the desired brilliancy.

Mortar body is a paste composed of 6 parts of clay, 3 of feldspar, 2 of silex, and 1 of china clay.

White and yellow figures upon dark-colored grounds are a good deal employed. To produce yellow impressions upon brown stoneware, ochre is ground up with a small quantity of antimony. The flux consists of flint glass and flints in equal weights. The composition for white designs is made by grinding silex up with that flux, and printing it on, as for blue colors, upon brown or other colored stoneware, which shows off the light hues.

English porcelain or china.—Most of this belongs to the class called tender or soft porcelain by the French and German manufacturers. It is not, therefore, composed simply of *kaolin* and *petuntse.* The English china is generally baked at a much lower heat than that of Sèvres, Dresden, and Berlin; and it is covered with a mere glass. Being manufactured upon a prodigious scale, with great economy and certainty, and little expenditure of fuel, it is sold at a very moderate price compared with the foreign porcelain, and in external appearance is now not much inferior.

Some of the English porcelain has been called ironstone china. This is composed usually of 60 parts of Cornish stone, 40 of china clay, and 2 of flint glass; or of 42 of the feldspar, the same quantity of clay, 10 parts of flints ground, and 8 of flint glass.

The glaze for the first composition is made with 20 parts of feldspar, 15 of flints, 6 of red lead, and 5 of soda, which are fritted together; with 44 parts of the frit, 22 parts of flint glass, and 15 parts of white lead, are ground.

The glaze for the second composition is formed of 8 parts of flint glass, 36 of feldspar, 40 of white lead, and 20 of silex (ground flints.)

The English manufacturers employ three sorts of compositions for the porcelain biscuit; namely, two compositions not fritted; one of them for the ordinary table service; another for the dessert service and tea dishes; the third, which is fritted, corresponds to the paste used in France for sculpture; and with it all delicate kinds of ornaments are made.

	First composition.	Second composition.		Third composition.	
Ground flints - - -	75	- -	66	Lynn sand	150
Calcined bones - -	180	- -	100	- -	300
China clay - - -	40	- -	96	- -	100
Clay - - - -	70	Granite	80	Potash -	10

The glaze for the first two of the preceding compositions consists of, feldspar 45, flints 9, borax 21, flint glass 20, nickel 4. After fritting that mixture, add 12 parts of red lead. For the third composition, which is the most fusible, the glaze must receive 12 parts of ground flints, instead of 9; and there should be only 15 parts of borax, instead of 21.

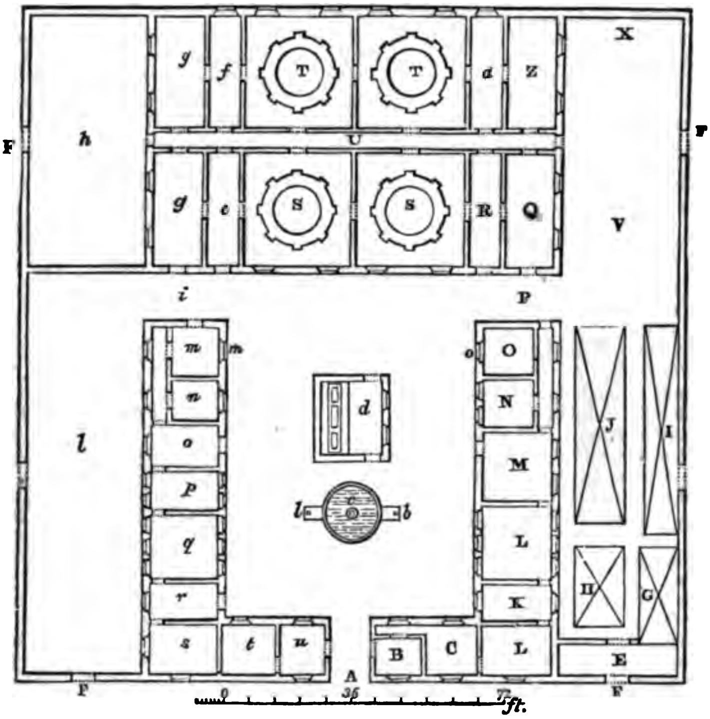
PLAN OF AN ENGLISH POTTERY.

A stoneware manufactory should be placed by the side of a canal or navigable river, because the articles manufactured do not well bear land carriage.

A Staffordshire pottery is usually built as a quadrangle, each side being about 100 feet long, the walls 10 feet high, and the ridge of the roof 5 feet more. The base of the edifice consists of a bed of bricks, 18 inches high, and 16 inches thick; upon which a mud wall in a wooden frame, called *pisé*, is raised. Cellars are formed in front of the buildings, as depots for the pastes prepared in the establishment. The wall of the yard or court is 9 feet high, and 18 inches thick.

Fig. 899, A, is the entrance door; B, the porter's lodge; C, a particular warehouse; D, workshop of the plaster-moulder; E, the clay depot; F, F, large gates, 6 feet 8 inches high; G, the winter evaporation stove; H, the shop for sifting the paste liquors; I, sheds for the paste liquor tubs; J, paste liquor pits; K, workshop for the moulder of hollow ware; L, ditto of the dish or plate moulder; M, the plate drying-stove; N, workshop of the biscuit-printers; O, ditto of the biscuit, with O′, a long window; P, passage leading to the paste liquor pits; Q, biscuit warehouse; R, place where the biscuit is cleaned as it comes out of the biscuit-kilns, S, S; T, T, enamel or glaze-kilns; U, long passage; V, space left for supplementary workshops; X, space appointed as a depot for the sagger fire-clay, as also for making the saggers; Z, the workshop for applying the glaze liquor to the biscuits; *a*, apartment for cleaning the glazed ware; *b*, *b*, pumps; *c*, basin; *d*, muffles; *e*, warehouse for the finished stoneware; *f*, that of the glazed goods; *g*, *g*, another warehouse; *h*, a large space for the smith's forge, carpenter's shop, packing room, depot of clays, saggers, &c. The packing and loading of the goods are performed in front of the warehouse, which has two outlets, in order to facilitate the work; *i*, a passage to the court or yard; *l*, a space for the wooden sheds for keeping hay, clay, and other miscellaneous articles; *m*, room for putting the biscuit into the saggers; *m'*, a long window; *n*, workshop with lathes and fly-wheels; *o*, drying-room; *p*, room for mounting or furnishing the pieces; *q*, repairing-room; *r*, drying-room of the goods roughly turned; *s*, rough turning or blocking-out room; *t*, room for beating the paste or dough; *u*, counting-house.

899



The declared value of the earthenware exported in 1836, was 837,774*l.*; in 1837, 558,682*l.*

There are from 33,000 to 35,000 tons of clay exported annually from Poole, in Dorsetshire, to the English and Scotch potteries. A good deal of clay is also sent from Devonshire and Cornwall.

The Spanish *alcarazzas*, or cooling vessels, are made porous, to favor the exudation of water through them, and maintain a constantly moist evaporating surface, Lasteyrie says, that granular sea salt is an ingredient of the paste of the Spanish alcarazzas; which being expelled partly by the heat of the baking, and partly by the subsequent watery percolation, leaves the body very open. The biscuit should be charged with a considerable proportion of sand, and very moderately fired.

OF PORCELAIN.

Porcelain is a kind of pottery ware whose paste is fine grained, compact, very hard, and faintly translucid; and whose biscuit softens slightly in the kiln. Its ordinary whiteness cannot form a definite character, since there are porcelain pastes variously colored. There are two species of porcelain, very different in their nature, the essential properties of which it is of consequence to establish; the one is called *hard*, and the other *tender*; important distinctions, the neglect of which has introduced great confusion into many treatises on this elegant manufacture.

Hard porcelain is essentially composed, first, of a natural clay containing some silica, infusible, and preserving its whiteness in a strong heat; this is almost always a true kaolin; secondly, of a flux, consisting of silica and lime, composing a quartzose feldspar rock, called *pe-tun-tse*. The glaze of this porcelain, likewise earthy, admits of no metallic substance or alkali.

Tender porcelain, styled also vitreous porcelain, has no relation with the preceding in its composition; it always consists of a vitreous frit, rendered opaque and less fusible by the addition of a calcareous or marly clay. Its glaze is an artificial glass or crystal, into which silica, alkalis, and lead enter.

This porcelain has a more vitreous biscuit, more transparent, a little less hard, and less fragile, but much more fusible than that of the hard porcelain. Its glaze is more glossy, more transparent, a little less white, much tenderer, and more fusible.

The biscuit of the hard porcelain made at the French national manufactory of Sèvres is generally composed of a kaolin clay, and of a decomposed feldspar rock; analogous to the china clay of Cornwall, and Cornish stone. Both of the above French materials come from Saint Yriex-la-perche, near Limoges.

After many experiments, the following composition has been adopted for the *service paste* of the royal manufactory of Sèvres; that is, for all the ware which is to be glazed; silica, 59; alumina, 35·2; potash, 2·2; lime, 3·3. The conditions of such a compound are pretty nearly fulfilled by taking from 63 to 70 of the washed kaolin or china clay, 22 to 15 of the feldspar, nearly 10 of flint powder, and about 5 of chalk. The glaze is composed solely of solid feldspar, calcined, crushed, and then ground fine at the mill. This rock pretty uniformly consists of silica 73, alumina 16·2, potash 8·4, and water 0·6.

The kaolin is washed at the pit, and sent in this state to Sèvres, under the name of *decanted earth*. At the manufactory it is washed and elutriated with care; and its slip is passed through fine sieves. This forms the plastic, infusible, and opaque ingredient to which the substance must be added which gives it a certain degree of fusibility and semi-transparency. The feldspar rock used for this purpose, should contain neither dark mica nor iron, either as an oxyde or sulphuret. It is calcined to make it crushable, under stamp-pestles driven by machinery, then ground fine in hornstone mills, as represented in *figs*. 897, 898, 899, and 900. This pulverulent matter, being diffused through water, is mixed in certain proportions, regulated by its quality, with the argillaceous *slip*. The mixture is deprived of the chief part of its water in shallow plaster pans without heat; and the resulting paste is set aside to ripen, in damp cellars, for many months.

When wanted for use, it is placed in hemispherical pans of plaster, which absorb the redundant moisture; after which it is divided into small lumps, and completely dried. It is next pulverized, moistened a little, and laid on a floor, and trodden upon by a workman marching over it with bare feet in every direction; the parings and fragments of soft moulded articles being intermixed, which improve the plasticity of the whole. When sufficiently tramped, it is made up into masses of the size of a man's head, and kept damp till required.

The dough is now in a state fit for the potter's lathe; but it is much less plastic than stoneware paste, and is more difficult to fashion into the various articles; and hence one cause of the higher price of porcelain.

The round plates and dishes are shaped on plaster moulds; but sometimes the paste is laid on as a crust, and at others it is turned into shape on the lathe. When a crust is to be made, a moistened sheep-skin is spread on a marble table; and over this the dough is extended with a rolling-pin supported on two guide-rules. The crust is then transferred over the plaster mould, by lifting it upon the skin; for it wants tenacity to bear raising by itself. When the piece is to be fashioned on the lathe, a lump of the dough is thrown on the centre of the horizontal wooden disc, and turned into form as directed in treating of stoneware, only it must be left much thicker than in its finished state. After it dries to a certain degree on the plaster mould, the workman replaces it on the lathe, by moistening it on its base with a wet sponge, and finishes its form with an iron tool. A good workman at Sèvres makes no more than from 15 to 20 porcelain plates in a day; whereas an English potter, with two boys, makes from 1000 to 1200 plates of stoneware in the same time. The pieces which are not round, are shaped in plaster moulds, and finished by hand. When the articles are very large, as wash-hand basins, salads, &c., a flat cake is spread above a skin on the marble slab, which is then applied to the mould with the sponge, as for plates; and they are finished by hand.

The projecting pieces, such as handles, beaks, spouts, and ornaments, are moulded and adjusted separately; and are cemented to the bodies of china-ware with slip, or porcelain dough thinned with water. In fact, the mechanical processes with porcelain and the finer stoneware are substantially the same; only they require more time and greater nicety. The least defect in the fabrication, the smallest bit added, an unequal pressure, the cracks of the moulds, although well repaired, and seemingly effaced in the clay shape, re-appear after it is baked. The articles should be allowed to dry very slowly; if hurried but a little, they are liable to be spoiled. When quite dry, they are taken to the kiln.

The kiln for hard porcelain at Sèvres, is a kind of tower in two flats, constructed of fire-bricks; and resembles, in other respects, the stoneware kiln already figured and described. The fuel is young aspin wood, very dry, and cleft very small; it is put into the apertures of the four outside furnaces or fire-mouths, which discharge their flame into the inside of the kiln; each floor being closed in above, by a dome pierced with holes. The whole is covered in by a roof with an open passage, placed at a proper distance from the uppermost dome. There is, therefore, no chimney proper so called. See STONE, ARTIFICIAL.

The raw pieces are put into the upper floor of the kiln; where they receive a heat of about the 60th degree of Wedgewood's pyrometer, and a commencement of baking, which, without altering their shape, or causing a perceptible shrinking of their bulk, makes them completely dry, and gives them sufficient solidity to bear handling. By this preliminary baking, the clay loses its property of forming a paste with water; and the pieces become fit for receiving the glazing coat, as they may be dipped in water without risk of breakage.

The glaze of hard porcelain is a feldspar rock; this being ground to a very fine powder, is worked into a paste with water mingled with a little vinegar. All the articles are dipped into this milky liquid for an instant; and as they are very porous, they absorb the water greedily, whereby a layer of the feldspar glaze is deposited on their surface, in a nearly dry state, as soon as they are lifted out. Glaze-pap is afterwards applied with a hair brush to the projecting edges, or any points where it had not taken; and the powder is then removed from the part on which the article is to stand, lest it should get fixed to its support in the fire. After these operations it is replaced in the kiln, to be completely baked.

The articles are put into saggers, like those of fine stoneware; and this operation is one of the most delicate and expensive in the manufacture of porcelain. The saggers are made of the plastic or potter's clay of Abondant, to which about a third part of cement of broken saggers has been added.

As the porcelain pieces soften somewhat in the fire, they cannot be set above each other, even were they free from glaze; for the same reason, they cannot be baked on tripods, several of them being in one case, as is done with stoneware. Every piece of porcelain requires a sagger for itself. They must, moreover, be placed on a perfectly flat surface, because in softening they would be apt to conform to the irregularities of a rough one. When therefore any piece, a soup plate for example, is to be *saggered*, there is laid on the bottom of the case a perfectly true disc or round cake of stoneware, made of the sagger material, and it is secured in its place on three small props of a clay-lute, consisting of potter's clay mixed with a great deal of sand. When the cake is carefully levelled, it is moistened, and dusted over with sand, or coated with a film of fire-clay slip, and the porcelain is carefully set on it. The sand or fire-clay hinders it from sticking to the cake. Several small articles may be set on the same cake, provided they do not touch one another.

The saggers containing the pieces thus arranged, are piled up in the kiln over each other, in the columnar form, till the whole space be occupied; leaving very moderate intervals between the columns to favor the draught of the fires. The whole being arranged with these precautions, and several others, too minute to be specified here, the door of the kiln is built up with 3 rows of bricks, leaving merely an opening 8 inches square, through which there is access to a sagger with the nearest side cut off. In this sagger are put fragments of porcelain intended to be withdrawn from time to time, in order to judge of the progress of the baking. These are called time-pieces or watches (*montres*). This opening into the watches is closed by a stopper of stoneware.

The firing begins by throwing into the furnace-mouths some pretty large pieces of white wood, and the heat is maintained for about 15 hours, gradually raising it by the addition of a larger quantity of the wood, till at the end of that period the kiln has a cherry-red color within. The heat is now greatly increased by the operation termed *covering the fire*. Instead of throwing billets vertically into the four furnaces, there is placed horizontally on the openings of these furnaces, aspin wood of a sound texture, cleft small, laid in a sloping position. The brisk and long flame which it yields dips into the tunnels, penetrates the kiln, and circulates round the sagger-piles. The heat augments rapidly, and, at the end of 13 or 15 hours of this firing, the interior of the kiln is so white, that the watches can hardly be distinguished. The draught, indeed, is so rapid at this time, that one may place his hand on the slope of the wood without feeling incommoded by the heat. Everything is consumed, no small charcoal remains, smoke is no longer produced, and even the wood-ash is dissipated. It is obvious that the kiln and the saggers must be composed of a very refractory clay, in order to resist such a fire. The heat in the Sèvres kilns mounts so high as the 134th degree of Wedgewood.

At the end of 15 or 20 hours of the great fire, that is, after from 30 to 36 hours' firing, the porcelain is baked; as is ascertained by taking out and examining the watches. The kiln is suffered to cool during 3 or 4 days, and is then opened and discharged. The sand strewed on the cakes, to prevent the adhesion of the articles to them, gets attached to their sole, and is removed by friction with a hard sandstone; an operation which one woman can perform for a whole kiln in less than 10 days; and is the last applied to hard porcelain, unless it needs to be returned into the hot kiln to have some defects repaired.

The materials of fine porcelain are very rare; and there would be no advantage in making a gray-white porcelain with coarser and somewhat cheaper materials, for the other sources of expense above detailed, and which are of most consequence, would still exist; while the porcelain, losing much of its brightness, would lose the main part of its value.

Its pap or dough, which requires tedious grinding and manipulation, is also more difficult to work into shapes, in the ratio of 80 to 1, compared to fine stoneware. Each porcelain plate requires a separate sagger; so that 12 occupy in the kiln a space sufficient for at least 38 stoneware plates. The temperature of a hard porcelain kiln being very high, involves a proportionate consumption of fuel and waste of saggers. With 40 *steres* (cubic metres) of wood, 12,000 stoneware plates may be completely fired, both in the biscuit and glaze kilns; while the same quantity of wood would bake at most only 1000 plates of porcelain.

To these causes of high price, which are constant and essential, we ought to add the numerous accidents to which porcelain is exposed at every step of its preparation, and particularly in the kiln; these accidents damage upwards of one third of the pieces, and frequently more, when articles of singular form and large dimensions are adventured.

The best English porcelain is made from a mixture of the Cornish kaolin (called china clay), ground flints, ground Cornish stone, and calcined bones in powder, or bone-ash, besides some other materials, according to the fancy of the manufacturers. A liquid pap is made with these materials, compounded in certain proportions, and diluted with water. The fluid part is then withdrawn by the absorbent action of dry stucco basins or pans. The dough, brought to a proper stiffness, and perfectly worked and kneaded on the principles detailed above, is fashioned on the lathe, by the hands of modellers, or by pressure in moulds. The pieces are then baked to the state of biscuit in a kiln, being enclosed, of course, in saggers.

This biscuit has the aspect of white sugar, and being very porous, must receive a vitreous coating. The glaze consists of ground feldspar or Cornish stone. Into this, diffused in water, along with a little flint-powder and potash, the biscuit ware is dipped, as already described, under stoneware. The pieces are then fired in the glaze-kiln, care being taken, before putting them into their saggers, to remove the glaze powder from their bottom parts, to prevent their adhesion to the fire-clay vessel.

TENDER PORCELAIN.

Tender porcelain, or soft china-ware, is made with a vitreous frit, rendered less fusible and opaque by an addition of white marl or bone-ash. The frit is, therefore, first prepared. This, at Sèvres, is a composition, made with some nitre, a little sea salt, Alicant barilla, alum, gypsum, and much silicious sand or ground flints. That mixture is subjected to an incipient pasty fusion in a furnace, where it is stirred about to blend the materials well; and thus a very white spongy frit is obtained. It is pulverized, and to every three parts of it, one of the white marl of Argenteuil is added; and when the whole are well ground, and intimately mixed, the paste of tender porcelain is formed.

As this paste has no tenacity, it cannot bear working till a mucilage of gum or black soap be added, which gives it a kind of plasticity, though even then it will not bear the lathe. Hence it must be fashioned in the press, between two moulds of plaster. The pieces are left thicker than they should be; and when dried, are finished on the lathe with iron tools.

In this state they are baked, without any glaze being applied; but as this porcelain softens far more during the baking than the hard porcelain, it needs to be supported on every side. This is done by baking on earthen moulds all such pieces as can be treated in this way, namely, plates, saucers, &c. The pieces are reversed on these moulds, and undergo their shrinkage without losing their form. Beneath other articles, supports of a like paste are laid, which suffer in baking the same contraction as the articles, and of course can serve only once. In this operation saggers are used, in which the pieces and their supports are fired.

The kiln for the tender porcelain at Sèvres is absolutely similar to that for the common stoneware; but it has two floors; and while the biscuit is baked in the lower story, the glaze is fused in the upper one; which causes considerable economy of fuel. The glaze of soft porcelain is a species of glass or crystal prepared on purpose. It is composed of flint, silicious sand, a little potash or soda, and about two fifth parts of lead oxyde. This mixture is melted in crucibles or pots beneath the kiln. The resulting glass is ground fine, and diffused through water mixed with a little vinegar to the consistence of cream. All the pieces of biscuit are covered with this glazy matter, by pouring this slip over them, since their substance is not absorbent enough to take it on by immersion.

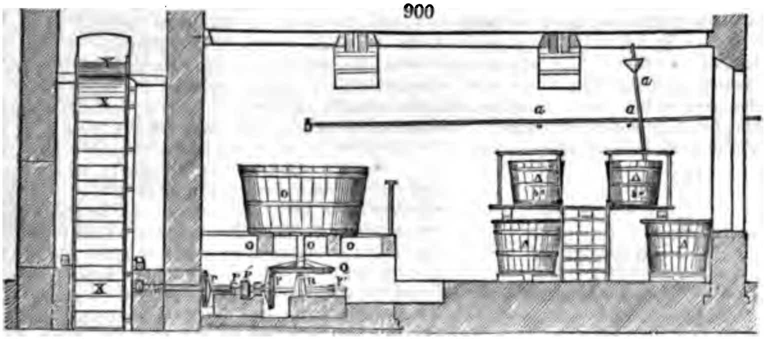
The pieces are encased once more each in a separate sagger, but without any supports; for the heat of the upper floor of the kiln, though adequate to melt the glaze, is not strong enough to soften the biscuit. But as this first vitreous coat is not very equal, a second one is applied, and the pieces are returned to the kiln for the third time. See STONE, ARTIFICIAL, for a view of this kiln.

The manufacture of soft porcelain is longer and more difficult than that of hard; its biscuit is dearer, although the raw materials may be found everywhere; and it furnishes also more refuse. Many of the pieces split asunder, receive fissures, or become deformed in the biscuit-kiln, in spite of the supports; and this vitreous porcelain, moreover, is always yellower, more transparent, and incapable of bearing rapid transitions of temperature, so that even the heat of boiling water frequently cracks it. It possesses some advantages as to painting, and may be made so gaudy and brilliant in its decorations, as to captivate the vulgar eye.

DESCRIPTION OF THE PORCELAIN MILL.

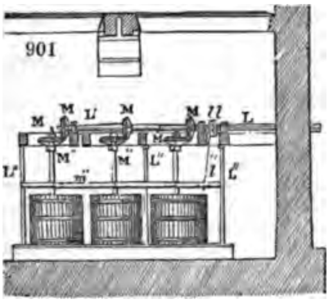
1. The following figures of a feldspar and flint mill are taken from plans of apparatus lately constructed by Mr. Hall of Dartford, and erected by him in the royal manufactory of Sèvres. There are two similar sets of apparatus, *fig.* 900, which may be employed together or in succession; composed each of an elevated tub A, and of three successive vats of reception A′, and two behind it, whose top edges are upon a lower level than the bottom of the casks A, A, to allow of the liquid running out of them with a sufficient slope. A proper charge of kaolin is first put into the cask A, then water is gradually run into it by the gutter adapted to the stopcock *a*, after which the mixture is agitated powerfully in every direction by hand with the stirring-bar, which is hung within a hole in the ceiling, and has at its upper end a small tin-plate funnel to prevent dirt or rust from dropping down into the clay. The stirrer may be raised or lowered so as to touch any part of the cask. The semi-fluid mass is left to settle for a few minutes, and then the finer argillaceous pap is run off by the stopcock *a′*, placed a little above the gritty deposite, into the zinc pipe which conveys it into one of the tubs A′; but as this semi-liquid matter may still contain some granular substances, it must be passed through a sieve before it is admitted into the tub. There is, therefore, at the spot upon the tub where the zinc pipe terminates, a wire-cloth sieve, of an extremely close texture, to receive the liquid paste. This sieve is shaken upon its support, in order to make it discharge the washed argillaceous kaolin. After the clay has subsided, the water is drawn off from its surface by a zinc syphon. The vats A′ have covers, to protect their contents from dust. In the pottery factories of England, the agitation is produced by machinery, instead of the hand. A vertical shaft, with horizontal or oblique paddles, is made to revolve in the vats for this purpose.

900



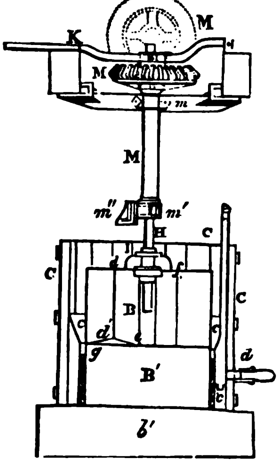
The small triturating mill is represented in *fig.* 901. There are three similar grinding-tubs on the same line. The details of the construction are shown in *figs.* 902, 903, where it is seen to consist principally of a revolving millstone B (*fig.* 902), of a fast or sleeper millstone B′, and of a vat C, hooped with iron, with its top raised above the upper millstone. The lower block of hornstone rests upon a very firm basis, *b′*; it is surrounded immediately by the strong wooden circle *c*, which slopes out funnel-wise above, in order to throw back the earthy matters as they are pushed up by the attrition of the stones. That piece is hollowed out, partially to admit the key c, opposite to which is the faucet and spigot *c'*, for emptying the tub. When one operation is completed, the key c is lifted out by means of a peg put into the holes at its top; the spigot is then drawn, and the thin paste is run out into vats. The upper grindstone, B *d*, like the lower one, is about two feet in diameter, and must be cut in a peculiar manner. At first there is scooped out a hollowing in the form of a sector, denoted by *d e f*, *fig.* 903; the arc *d f* is about one sixth of the circumference, so that the vacuity of the turning grindstone is one sixth of its surface; moreover, the stone must be channelled, in order to grind or crush the hard gritty substances. For this purpose, a wedge-shaped groove *d e g*, about an inch and a quarter deep, is made on its under face, whereby the stone, as it turns in the direction indicated by the arrow, acts with this inclined plane upon all the particles in its course, crushing them and forcing them in between the stones, till they be triturated to an impalpable powder. When the grindstone wears unequally on its lower surface, it is useful to trace upon it little furrows, proceeding from the centre to the circumference, like those shown by the dotted lines *e' e''*. It must, moreover, be indented with rough points by the hammer.

901



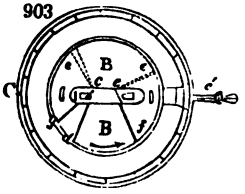
The turning horn-stone block is set in motion by the vertical shaft H, which is fixed by the clamp-iron cross I to the top of the stone. When the stone is new, its thickness is about 14 inches, and it is made to answer for grinding till it be reduced to about 8 inches, by lowering the clamp I upon the shaft, so that it may continue to keep its hold of the stone. The manner in which the grindstones are turned, is obvious from inspection of *fig.* 901, where the horizontal axis L, which receives its impulsion from the great water-wheel, turns the prolonged shaft L', or leaves it at rest, according as the clutch *l*, *l'*, is locked or opened. This second shaft bears the three bevel wheels M, M, M. These work in three corresponding bevel wheels M' M' M', made fast respectively to the three vertical shafts of the millstones, which pass through the cast iron guide tubes M'' M''. These are fixed in a truly vertical position by the collar-bar *m''*, *m'*, *fig.* 902. In this figure we see at *m* how the strong cross-bar of cast iron is made fast to the wooden beams which support all the upper mechanism of the mill-work. The bearing *m'* is disposed in an analogous manner; but it is supported against two cast iron columns, shown at L'' L'', in *fig.* 901. The guide tubes M'' are bored smooth for a small distance from each of their extremities, and their interjacent calibre is wider, so that the vertical shafts touch only at two places. It is obvious, that whenever the shaft L' is set a-going, it necessarily turns the wheels M and M', and their guide tubes M''; but the vertical shaft may remain either at rest, or revolve, according to the position of the lever click or catch K, at the top, which is made to slide upon the shaft, and can let fall a finger into a vertical groove cut in the surface of that shaft. The clamp-fork of the click is thus made to catch upon the horizontal bevel-wheel M', or to release it, according as the lever K is lowered or lifted up. Thus each millstone may be thrown out of or into gear at pleasure.

902



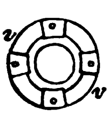
These stones make upon an average 11 or 12 turns in a minute, corresponding to three revolutions of the water-wheel, which moves through a space of 3 feet 4 inches in the second, its outer circumference being 66 feet. The weight of the upper stone, with its iron mountings, is about 6 cwts., when new. The charge of each mill in dry material is 2 cwts.; and the water may be estimated at from one half to the whole of this weight; whence the total load may be reckoned to be at least 3 cwts.; the stone, by displacement of the magma, loses fully 400 pounds of its weight, and weighs therefore in reality only 2 cwts. It is charged in successive portions, but it is discharged all at once. *When the* grinding of the silicious or feldspar matters is nearly complete, a remarkable

903



phenomenon occurs; the substance precipitates to the bottom, and assumes in a few seconds so strong a degree of cohesion, that it is hardly possible to restore it again to the pasty or mamga state; hence if a millstone turns too slowly, or if it be accidentally stopped for a few minutes, the upper stone gets so firmly cemented to the under one, that it is difficult to separate them. It has been discovered, but without knowing why, that a little vinegar added to the water of the magma almost infallibly prevents that sudden stiffening of the deposite and stoppage of the stones. If the mills come to be set fast in this way, the shafts or gearing would be certainly broken, were not some safety provision to be made in the machinery against such accidents. Mr. Hall's contrivance to obviate the above danger is highly ingenious. The clutch *l*, *l'*, *fig.* 901, is not a locking crab, fixed in the common way, upon the shaft L; but it is composed, as shown in *figs.* 904, 905, 906, 907, of a hoop *u*, fixed upon the shaft by means of a key, of a collar *v*, and of a flat ring or washer *x*, with four projections, which are fitted to the collar *v*, by four bolts *y*. *Fig.* 905 represents the collar *v* seen in front; that is, by the face which carries the clutch teeth; and *fig.* 906 represents its other face, which receives the flat ring *x*, *fig.* 907, in four notches corresponding to the four projections of the washer-ring. Since the ring *u* is fixed upon the shaft L, and necessarily turns with it, it has the two other pieces at its disposal, namely, the collar *v*, and the washer *x*, because they are always connected with it by the four bolts *y*, so as to turn with the ring *u*, when the resistance they encounter upon the shaft L' is not too great, and to remain at rest, letting the ring *u* turn by itself, when that resistance increases to a certain pitch. To give this degree of friction, we need only interpose the leather washers *z*, *z'*, *fig.* 904; and now as the collar *coupling-box*, *v*, slides pretty freely upon the ring *u*, it is obvious that by tightening more or less the screw bolts *y*, these washers will become as it were a lateral brake, to tighten more or less the bearing of the ring *u*, to which they are applied; by regulating this pressure, everything may be easily adjusted. When the resistance becomes too great, the leather washers, pressed upon one side by the collar *v*, of the washer *x*, and rubbed upon the other side by the prominence of the ring *u*, get heated to such a degree, that they are apt to become carbonized, and require replacement.

905



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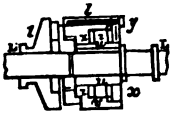

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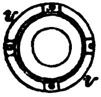

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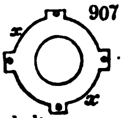


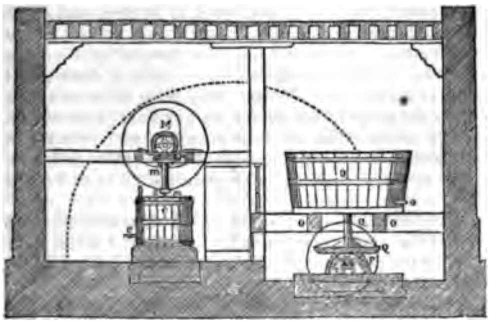
This safety clutch may be recommended to the notice of mechanicians, as susceptible of beneficial application in a variety of circumstances.

GREAT PORCELAIN MILL.

The large feldspar and kaolin mill, made by Mr. Hall, for Sèvres, has a flat bed of hornstone, in one block, laid at the bottom of a great tub, hooped strongly with iron. In most of the English potteries, however, that bed consists of several flat pieces of chert or hornstone, laid level with each other. There are, as usual, a spigot and faucet at the side, for drawing off the liquid paste. The whole system of the mechanism is very substantial, and is supported by wooden beams.

The following is the manner of turning the upper blocks. In *fig.* 900 the main horizontal shaft P bears at one of its extremities a toothed wheel, usually mounted upon the periphery of the great water-wheel (*fig.* 908 shows this toothed wheel by a dotted line) at its other end; P carries the fixed portion *p* of a coupling-box, similar to the one just described as belonging to the little mill. On the prolongation of P, there is a second shaft P', which bears the moveable portion of that box, and an upright bevel wheel P''. Lastly, in *figs.* 900 and 908, there is shown the vertical shaft Q, which carries at its upper end a large horizontal cast-iron wheel Q', not seen in this view, because it is sunk within the upper surface of the turning hornstone, like the clamp *d*, *f*, in *fig.* 902. At the lower end of the shaft Q, there is the bevel wheel Q'', which receives motion from the wheel P'', *fig.* 900.

908



The shaft P always revolves with the water-wheel; but transmits its motion to the shaft P′ only when the latter is thrown into gear with the coupling-box *p′*, by means of its forked lever. Then the bevel wheel P′ turns round with the shaft P′, and communicates its rotation to the bevel wheel Q″, which transmits it to the shaft Q, and to the large cast-iron wheel, which is sunk into the upper surface of the revolving hornstone.

The shaft Q is supported and centred by a simple and solid adjustment; at its lower part, it rests in a step R′, which is supported upon a cast-iron arch Q′, seen in profile in *fig.* 900; its base is solidly fixed by four strong bolts. Four set screws above R, *fig.* 908, serve to set the shaft Q truly perpendicular; thus supported, and held securely at its lower end, in the step at R, *figs.* 900 and 908, it is embraced near the upper end by a brass bush or collar, composed of two pieces, which may be drawn closer together by means of a screw. This collar is set into the summit of a great truncated cone of cast-iron, which rises within the tub through two thirds of the thickness of the hornstone bed; having its base firmly fixed by bolts to the bottom of the tub, and having a brass collet to secure its top. The iron cone is cased in wood. When all these pieces are well adjusted and properly screwed up, the shaft Q revolves without the least vacillation, and carries round with it the large iron wheel Q′, cast in one piece, and which consists of an outer rim, three arms or radii, and a strong central nave, made fast by a key to the top of the shaft Q, and resting upon a shoulder nicely turned to receive it. Upon each of the three arms, there are adjusted, with bolts, three upright substantial bars of oak, which descend vertically through the body of the revolving mill to within a small distance of the bed-stone; and upon each of the three arcs of that wheel-ring, comprised between its three strong arms, there are adjusted, in like manner, five similar uprights, which fit into hollows cut in the periphery of the moving stone. They ought to be cut to a level at their lower part, to suit the slope of the bottom of the tub *o*, *figs.* 900 and 908, so as to glide past it pretty closely, without touching.

The speed of this large mill is eight revolutions in the minute. The turning hornstone describes a mean circumference of 141⅜ inches (its diameter being 45 inches), and of course moves through about 100 feet per second. The tub o, is 52 inches wide at bottom, 56 at the surface of the sleeper block (which is 16 inches thick), and 64 at top, inside measure. It sometimes happens that the millstone throws the pasty mixture out of the vessel, though its top is 6 inches under the lip of the tub *o;* an inconvenience which can be obviated only by making the pap a little thicker; that is, by allowing only from 25 to 30 per cent. of water; then its density becomes nearly equal to 2·00, while that of the millstones themselves is only 2·7; whence, supposing them to weigh only 2 cwts., there would remain an effective weight of less than ½ cwt. for pressing upon the bottom and grinding the granular particles. This weight appears to be somewhat too small to do much work in a short time; and therefore it would be better to increase the quantity of water, and put covers of some convenient form over the tubs. It is estimated that this mill will grind nearly 5 cwts. of hard kaolin or feldspar gravel, in 24 hours, into a proper pap.

To the preceding methodical account of the porcelain manufacture, I shall now subjoin some practical details relative to certain styles of work, with comparisons between the methods pursued in this country and upon the Continent, but chiefly by our jealous rivals the French.

The blue printed ware of England has been hitherto a hopeless object of emulation in France. M. Alexandre Brongniart, membre de l'Institut, and director of the *Manufacture Royal de Sèvres*, characterizes the French imitations of the *Fayence fine, ou Anglaise*, in the following terms: "Les défauts de cette poterie, qui tiennent à sa nature, sont de ne pouvoir aller sur le feu pour les usages domestiques, et d'avoir un vernis tendre, qui se laisse aisément entamer par les instruments d'acier et de fer. Mais lorsque cette poterie est mal fabriquée, ou fabriquée avec une économie mal entendue, ses défauts deviennent bien plus graves; son vernis jaunâtre et tendre tressaille souvent; il se laisse entamer ou user avec la plus grande facilité par les instruments de fer, ou par l'usage ordinaire. Les fissures que ce tressaillement ou ces rayures ouvrent dans le vernis permettent aux matières grasses de pénétrer dans le biscuit, que dans les poteries affectées de ce défaut, a presque toujours une texture lâche; les pièces se salissent, s'empuantissent, et se brisent même avec la plus grande facilité."*

What a glaze, to be scratched or grooved with soft iron; to fly off in scales, so as to let grease soak into the biscuit or body of the ware; to become foul, stink, and break with the utmost ease! The refuse crockery of the coarsest pottery works in the United Kingdom would hardly deserve such censure.

In the minutes of evidence of the *Enquête Ministérielle*, published in 1835, MM. de Saint Cricq and Lebeuf, large manufacturers of pottery-ware at Creil and Montereau, give a very gratifying account of the English stoneware manufacture. They declare that the English possess magnificent mines of potter's clay, many leagues in extent; while those of the

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* Dict. Technologique, tom. xvii., article Poteries, p. 253.

French are mere patches or *pots*. Besides, England, they say, having upwards of 200 potteries, can constantly employ a great many public flint-mills, and thereby obtain that indispensable material of the best quality, and at the lowest rate. "The mill erected by M. Brongniart, at Sèvres, does its work at twice the price of the English mills. The fuel costs in England one fourth of what it does in France. The expense of a kiln-round, in the latter country, is 200 francs; while in the former it is not more than 60." After a two-months tour among the English potteries, these gentlemen made the following additional observations to their first official statement:—

"The clay, which goes by water carriage from the counties of Devon and Dorset, into Staffordshire, to supply more than 200 potteries, clustered together, is delivered to them at a cost of 4 francs (3*s.* 2*d.*) the 100 kilogrammes (2 cwt.); at Creil, it costs 4*f.* 50*c.*, and at Mintereau, only 2*f.* 40*c.* There appears, therefore, to be no essential difference in the price of the clay; but the quality of the English is much superior, being incontestably whiter, purer, more homogeneous, and not turning red at a high heat, like the French." The grinding of the flints costs the English potter 4½*d.* per 100 kilos., and the French 6*d.*; but as that of the latter is in general ground dry, it is a coarser article. The kaolin, or china clay, is imported from Cornwall for the use of many French potteries; but the transport of merchandise is so ill managed in France, that while 2 cwts. cost in Staffordshire only 8*f.* 75*c.* (about 7*s.* 1*d.*), they cost 12*f.* at Creil, and 13*f.* 50*c.* at Montereau. The white lead and massicot, so much employed for glazes, are 62 per cent. dearer to the French potters than the English. As no French mill has succeeded in making unsized paper fit for printing upon stoneware, our potters are under the necessity of fetching it from England; and, under favor of our own custom-house, are allowed to import it at a duty of 165*f.* per 100 kilogrammes, or about 8*d.* per pound English. No large stock of materials need be kept by the English, because every article may be had when wanted from its appropriate wholesale dealers; but the case is quite different with the French, whose stocks, even in small works, can never safely be less in value than 150,000*f.* or 200,000*f.*; constituting a loss to them, in interest upon their capital, of from 7,500*f.* to 10,000*f.* per annum. The capital sunk in buildings is far less in England than in France, in consequence of the different styles of erecting stoneware factories in the two countries. M. de Saint Cricq informs us, that Mr. Clewes, of Shelton, rents his works for 10,000*f.* (380*l.*) per annum; while the similar ones of Creil and Montereau, in France, have cost each a capital outlay of from 500,000*f.* to 600,000*f.*, and in which the products are not more than one half of Mr. Clewes'. "This forms a balance against us," says M. St. C., "of about 20,000*f.* per annum; or nearly 800*l.* sterling. Finally, we have the most formidable rival to our potteries in the extreme dexterity of the English artisans. An enormous fabrication permits the manufacturers to employ the same workmen during the whole year upon the same piece; thus I have seen at Shelton a furnisher, for sixpence, turn off 100 pieces, which cost at Creil and Montereau 30 sous (1*s.* 2½*d.*); yet the English workman earns 18*f.* 75*c.* a week, while the French never earns more than 15*f.* I have likewise seen an English moulder expert enough to make 25 waterpots a day, which, at the rate of 2*d.* a piece, bring him 4*s.* 2*d.* of daily wages; while the French moulder, at daily wages also of 4*s.* 2*d.*, turns out of his hands only 7, or at most 8 pots. In regard to hollow wares, the English may be fairly allowed to have an advantage over us, in the cost of labor, of 100 per cent.; which they derive from the circumstance, that there are in Staffordshire 60,000 operatives, men, women, and children, entirely dedicated to the stoneware manufacture; concentrating all their energies within a space of 10 square leagues. Hence a most auspicious choice of good practical potters, which cannot be found in France."

M. Saint Amans, a French gentleman, who spent some years in Staffordshire, and has lately erected a large pottery in France, says the English surpass all other nations in manufacturing a peculiar stoneware, remarkable for its lightness, strength, and elegance; as also in printing blue figures upon it of every tint, equal to that of the Chinese, by processes of singular facility and promptitude. After the biscuit is taken out of the kiln, the fresh impression of the engraving is transferred to it from thin unsized paper, previously immersed in strong soap water; the ink for this purpose being a compound of arseniate of cobalt with a flux, ground up with properly boiled linseed oil. The copper-plates are formed by the graving tool with deeper or shallower lines, according to the variable depth of shades in the design. The cobalt pigment, on melting, spreads so as to give the soft effect of water-color drawing. The paper, being still moist, is readily applied to the slightly rough and adhesive surface of the biscuit, and may be rubbed on more closely by a dossil of flannel. The piece is then dipped in a tub of water, whereby the paper gets soft, and may be easily removed, leaving upon the pottery the pigment of the engraved impression. After being gently dried, the piece is dipped into the glaze mixture, and put into the enamel oven.

Composition of the Earthy Mixtures.

The basis of the English stoneware is, as formerly stated, a bluish clay, brought from Dorsetshire and Devonshire, which lies at the depth of from 25 to 30 feet beneath the surface. It is composed of about 24 parts of alumina, and 76 of silica, with some other ingredients in very small proportions. This clay is very refractory in high heats, a property which, joined to its whiteness when burned, renders it peculiarly valuable for pottery. It is also the basis of all the yellow biscuit-ware called *cream color*, and in general of what is called the *printing body;* as also for the semi-vitrified porcelain of Wedgewood's invention, and of the tender porcelain.

The constituents of the stoneware are, that clay, the powder of calcined flints, and of the decomposed feldspar called Cornish stone. The proportions are varied by the different manufacturers. The following are those generally adopted in one of the principal establishments of Staffordshire:—

For *cream color*,	Silex or ground flints - - - - - - -	20 parts.
	Clay - - - - - - - - -	100
	Cornish stone - - - - - - - -	2

Composition of the Paste for receiving the Printing Body under the Glaze.

For this purpose the proportions of the flint and the feldspar must be increased. The substances are mixed separately with water into the consistence of a thick cream, which weighs per pint, for the flints 32 ounces, and for the Cornish stone 28. The china clay of Cornwall is added to the same mixture of flint and feldspar, when a finer pottery or porcelain is required. That clay cream weighs 24 ounces per pint. These 24 ounces in weight are reduced to one third of their bulk by evaporation. The pint of dry Cornish clay weighs 17 ounces, and in its first pasty state 24, as just stated. The dry flint powder weighs 14½ ounces per pint; which when made into a cream weighs 32 ounces. To 40 measures of Devonshire clay-cream there are added,

13	measures of	flint liquor.
12	—	Cornish clay ditto.
1	—	Cornish stone ditto.

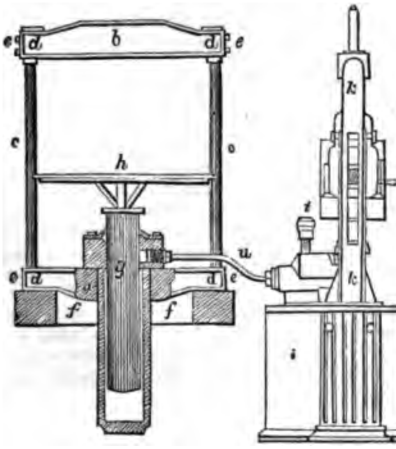
The whole are well mixed by proper agitation, half dried in the *troughs* of the slip-kiln, and then subjected to the machine for cutting up the clay into junks. The above paste, when baked, is very white, hard, sonorous, and susceptible of receiving all sorts of impressions from the paper engravings. When the silica is mixed with the alumina in the above proportions, it forms a compact ware, and the impression remains fixed between the biscuit and the glaze, without communicating to either any portion of the tint of the metallic color employed in the engraver's press. The feldspar gives strength to the biscuit, and renders it sonorous after being baked; while the china clay has the double advantage of imparting an agreeable whiteness and great closeness of grain.

PRECIPITATE, is any matter separated in minute particles from the bosom of a fluid, which subsides to the bottom of the vessel in a pulverulent form.

PRECIPITATION, is the actual subsidence of a precipitate.

PRESS, HYDRAULIC. Though the explanation of the principles of this powerful machine belongs to a work upon mechanical engineering, rather than to one upon

909



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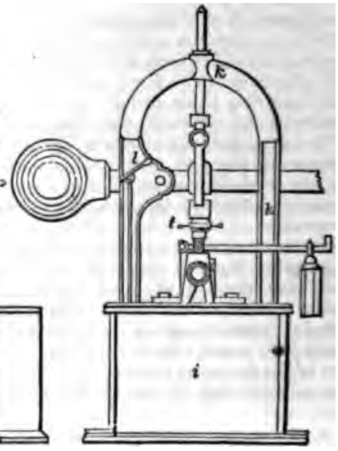
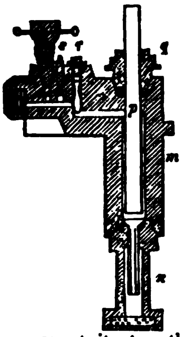


manufactures, yet as it is often referred to in this volume, a brief description of it cannot be unacceptable to many of my readers.

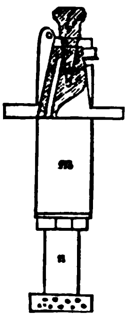
The framing consists of two stout cast iron plates *a*, *b*, which are strengthened by projecting ribs, not seen in the section, *fig.* 909. The top or crown plate *b*, and the base-plate *a*, *a*, are bound most firmly together by 4 cylinders of the best wrought iron, *c*, *c*, which pass up through holes near the ends of the said plates, and are fast wedged in them. The flat pieces *e*, *e*, are screwed to the ends of the crown and base plates, so as to bind the columns laterally. *f*, is the hollow cylinder of the press, which, as well as the ram *g*, is made of cast iron. The upper part of the cavity of the cylinder is cast narrow, but is truly and smoothly rounded at the boring-mill, so as to fit pretty closely round a well-turned ram or piston; the under part of it is left somewhat wider in the casting. A stout cup of leather, perforated in the middle, is put upon the ram, and serves as a valve to render the neck of the cylinder perfectly water-tight, by filling up the space between it and the ram; and since the mouth of the cup is turned downwards, the greater the pressure of water upwards, the more forcibly are the edges of the leather valve pressed against the inside of the cylinder, and the tighter does the joint become. This was Bramah's beautiful invention.

Upon the top of the ram, the press-plate or table, strengthened with projecting ridges, rests, which is commonly called the follower, because it follows the ram closely in its descent. This plate has a half-round hole at each of its four corners, corresponding to the shape of the four iron columns along which it glides in its up-and-down motions of compression and relaxation.

911



912



k, *k*, *figs.* 909 and 910, is the framing of a force pump with a narrow barrel; *i* is the well for containing water to supply the pump. To spare room in the engraving, the pump is set close to the press, but it may be removed to any convenient distance by lengthening the water-pipe *u*, which connects the discharge of the force pump with the inside of the cylinder of the press. *Fig.* 911 is a section of the pump and its valves. The pump *m*, is of bronze; the suction-pipe *n*, has a conical valve with a long tail; the solid piston or plunger *p*, is smaller than the barrel in which it plays, and passes at its top through a stuffing-box *q*; *r* is the pressure-valve, *s* is the safety-valve, which, in *fig.* 910, is seen to be loaded with a weighted lever; *t* is the discharge-valve, for letting the water escape, from the cylinder beneath the ram, back into the well. See the winding passages in *fig.* 912. *u* is the tube which conveys the water from the pump into the press-cylinder. In *fig.* 910 two centres of motion for the pump-lever are shown. By shifting the bolt into the centre nearest the pump-rod, the mechanical advantage of the workman may be doubled. Two pumps are generally mounted in one frame for one hydraulic press; the larger to give a rapid motion to the ram at the beginning, when the resistance is small; the smaller to give a slower but more powerful impulsion, when the resistance is much increased. A pressure of 500 tons may be obtained from a well-made hydraulic press with a ten-inch ram, and a two and a one inch set of pumps. See STEARINE PRESS.

PRINCE'S METAL, or Prince Rupert's metal, is a modification of brass.

PRINTING INK. (*Encre d'imprimerie*, Fr.; *Buchdruckerfarbe*, Germ.) After reviewing the different prescriptions given by Moxon, Breton, Papillon, Lewis, those in Nicholson's and the Messrs. Aikins' Dictionaries, in Rees' Cyclopædia, and in the French Printer's Manual, Mr. Savage* says, that the Encyclopædia Britannica is the only work, to his knowledge, which has given a recipe by which a printing ink might be made, that could be used, though it would be of inferior quality, as acknowledged by the editor; for it specifies neither the qualities of the materials, nor their due proportions. The fine black ink made by Mr. Savage, has, he informs us, been pronounced by some of our first printers to be unrivalled; and has procured for him the large medal from the Society for the Encouragement of Arts.

1. *Linseed oil.*—Mr. Savage says, that the linseed oil, however long boiled, unless set fire to, cannot be brought into a proper state for forming printing ink; and that the flame may be most readily extinguished by the application of a pretty tight tin cover to the top of the boiler, which should never be more than half full. The French prefer nut oil to linseed; but if the latter be old, it is fully as good, and much cheaper, in this country at least.

2. *Black rosin* is an important article in the composition of good ink; as by melting

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* In his work on the Preparation of Printing Ink; 8vo., London, 1832.

it in the oil, when that ingredient is sufficiently boiled and burnt, the two combine, and form a compound approximating to a natural balsam, like that of Canada, which is itself one of the best varnishes that can be used for printing ink.

3. *Soap.*—This is a most important ingredient in printers' ink, which is not even mentioned in any of the recipes prior to that in the Encyclopædia Britannica. For want of soap, ink accumulates upon the face of the types, so as completely to clog them up after comparatively few impressions have been taken; it will not wash off without alkaline leys, and it skins over very soon in the pot. Yellow rosin soap is the best for black inks; for those of light and delicate shades, white curd soap is preferable. Too much soap is apt to render the impression irregular, and to prevent the ink from drying quickly. The proper proportion has been hit, when the ink works clean, without clogging the surface of the types.

4. *Lamp black.*—The vegetable lamp black, sold in firkins, takes by far the most varnish, and answers for making the best ink. See Black.

5. *Ivory black* is too heavy to be used alone as a pigment for printing ink; but it may be added with advantage by grinding a little of it upon a muller with the lamp black, for certain purposes; for instance, if an engraving on wood is required to be printed so as to produce the best possible effect.

6. *Indigo* alone, or with an equal weight of Prussian blue, added in small proportion, takes off the brown tone of certain lamp black inks. Mr. Savage recommends a little Indian red to be ground in with the indigo and Prussian blue, to give a rich tone to the black ink.

7. *Balsam of capivi,* as sold by Mr. Allen, Plough-court, Lombard-street, mixed, by a stone and a muller, with a due proportion of soap and pigment, forms an extemporaneous ink, which the printer may employ very advantageously when he wishes to execute a job in a peculiarly neat manner. Canada balsam does not answer quite so well.

After the smoke begins to rise from the boiling oil, a bit of burning paper stuck in the cleft end of a long stick should be applied to the surface, to set it on fire, as soon as the vapor will burn; and the flame should be allowed to continue (the pot being meanwhile removed from over the fire, or the fire taken from under the pot), till a sample of the varnish, cooled upon a pallet-knife, draws out into strings of about half an inch long between the fingers. To six quarts of linseed oil thus treated, six pounds of rosin should be gradually added, as soon as the froth of the ebullition has subsided. Whenever the rosin is dissolved, one pound and three quarters of dry brown soap, of the best quality, cut into slices, is to be introduced cautiously, for its water of combination causes a violent intumescence. Both the rosin and soap should be well stirred with the spatula. The pot is to be now set upon the fire, in order to complete the combination of all the constituents.

Put next of well ground indigo and Prussian blue, each 2½ ounces, into an earthen pan, sufficiently large to hold all the ink, along with 4 pounds of the best mineral lamp black, and 3½ pounds of good vegetable lamp black; then add the warm varnish by slow degrees, carefully stirring, to produce a perfect incorporation of all the ingredients. This mixture is next to be subjected to a mill, or slab and muller, till it be levigated into a smooth uniform paste.

One pound of a superfine printing ink may be made by the following recipe of Mr. Savage:—Balsam of capivi, 9 oz.; lamp black, 3 oz.; indigo and Prussian blue, together, p. æq. 1¼ oz.; Indian red, ¾ oz.; turpentine (yellow) soap, dry, 3 oz. This mixture is to be ground upon a slab, with a muller, to an impalpable smoothness. The pigments used for colored printing inks are, carmine, lakes, vermilion, red lead, Indian red, Venetian red, chrome yellow, chrome red or orange, burnt *terra di Sienna,* gall-stone, Roman ochre, yellow ochre, verdigris, blues and yellows mixed for greens, indigo, Prussian blue, Antwerp blue, lustre, umber, sepia, browns mixed with Venetian red, &c.

PRINTING MACHINE. (*Typographie mécanique,* Fr.; *Druckmaschine,* Germ.) In reviewing those great eras of national industry, when the productive arts, after a long period of irksome vassalage, have suddenly achieved some new conquest over the inertia of matter, the contemplative mind cannot fail to be struck with the insignificant part which the academical philosopher has generally played in such memorable events.

Engrossed with barren syllogisms, or equational theorems, often little better than truisms in disguise, he nevertheless believes in the perfection of his attainments, and disdains to soil his hands with those handicraft operations at which all improvements in the arts must necessarily begin. He does not deem a manufacture worthy of his regard, till it has worked out its own grandeur and independence with patient labor and consummate skill. In this spirit the men of speculative science neglected for 60 years the steam engine of Newcomen, till the artisan Watt transformed it into an automatic prodigy; *they have* never deigned to illustrate by dynamical investigations the factory mechanisms of Arkwright, yet nothing in the whole compass of art deserves it so well; and though perfectly aware that revolvency is the leading law in the system of the universe, they have never thought of showing the workman that this was also the true principle of every automatic machine.

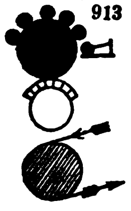
These remarks seem to be peculiarly applicable to book-printing, an art invented for the honor of learning and the glory of the learned, though they have done nothing for its advancement; yet by the overruling bounty of Providence it has eventually served as the great teacher and guardian of the whole family of man.

It has been justly observed by Mr. Cowper, in his ingenious lecture,* that no improvement had been introduced in this important art, from its invention till the year 1798, a period of nearly 350 years. In Dr. Dibdin's interesting account of printing, in the Bibliographical Decameron, may be seen representations of the early printing-presses, which exactly resemble the wooden presses in use at the present day. A new era has, however, now arrived, when the demands for prompt circulation of political intelligence require powers of printing newspapers beyond the reach of the most expeditious hand presswork.

For the first essential modification of the old press, the world is indebted to the late Earl Stanhope.† His press is formed of iron, without any wood; the table upon which the form of types is laid, as well as the platen or surface which immediately gives the impression, is of cast iron, made perfectly level; the platen being large enough to print a whole sheet at one pull. The compression is applied by a beautiful combination of levers, which give motion to the screw, cause the platen to descend with progressively increasing force till it reaches the type, when the power approaches the maximum; upon the infinite lever principle, the power being applied to straighten an obtuse-angled jointed lever. This press, however, like all its flat-faced predecessors, does not act by a continuous, but a reciprocating motion, and can hardly be made automatic; nor does it much exceed the old presses in productiveness, since it can turn off only 250 impressions per hour.

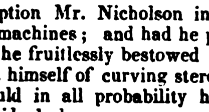
The first person who publicly projected a self-acting printing-press, was Mr. William Nicholson, the able editor of the Philosophical Journal, who obtained a patent in 1790-1, for imposing types upon a cylindrical surface; this disposition of types, plates, and blocks, being a new invention (see *fig.* 913); 2, for applying the ink upon the surface of the types, &c., by causing the surface of a cylinder smeared with the coloring-matter to roll over them; or else causing the types to apply themselves to the said cylinder. For the purpose of spreading the ink evenly over this cylinder, he proposed to apply three or more distributing rollers longitudinally against the inking cylinder, so that they might be turned by the motion of the latter. 3. "I perform," he says, "*all my impressions by the action* of a cylinder, or cylindrical surface; that is, I cause the paper to pass between two cylinders, one of which has the form of types attached to it, and forming part of its surface; and the other is faced with cloth, and serves to press the paper so as to take off an impression of the color previously applied; or otherwise I cause the form of types, previously colored, to pass in close and successive contact with the paper wrapped round a cylinder with woollen." (See *figs.* 913 and 914.)‡

913



Nicholson's for arched type.

914



Nicholson's for common type.

In this description Mr. Nicholson indicates pretty plainly the principal parts of modern printing machines; and had he paid the same attention to any one part of his invention which he fruitlessly bestowed upon attempts to attach types to a cylinder, or had he bethought himself of curving stereotype plates, which were then beginning to be talked of, he would in all probability have realized a working apparatus, instead of scheming merely ideal plans.

The first operative printing machine was undoubtedly contrived by, and constructed under the direction of, M. König, a clockmaker from Saxony, who, so early as the year 1804, was occupied in improving printing-presses. Having failed to interest the continental printers in his views, he came to London soon after that period, and submitted his plans to Mr. T. Bensley, our celebrated printer, and to Mr. R. Taylor, now one of the editors of the Philosophical Magazine.

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* On the recent improvements in printing, first delivered at the Royal Institution, February 22, 1828.

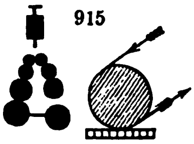
† Lord Stanhope is the only man of learning whose name figures in the annals of typography.

‡ The black parts in these little diagrams, 913—922, indicate the inking apparatus; the diagonal lines, the cylinders upon which the paper to be printed is applied; the perpendicular lines, the plates or types; and the arrows show the track pursued by the sheet of paper.

These gentlemen afforded Mr. König and his assistant Bauer, a German mechanic, liberal pecuniary support. In 1811, he obtained a patent for a method of working a common hand-press by power; but after much expense and labor he was glad to renounce the scheme. He then turned his mind to the use of a cylinder for communicating the pressure, instead of a flat plate; and he finally succeeded, some time before the 28th November, 1814, in completing his printing automaton; for on that day the editors of the Times informed their readers that they were perusing for the first time a newspaper printed by steam-impelled machinery; it is a day, therefore, which will be ever memorable in the annals of typography.

In that machine the form of type was made to traverse horizontally under the pressure cylinder, with which the sheet of paper was held in close embrace by means of a series of endless tapes. The ink was placed in a cylindrical box, from which it was extruded by means of a powerful screw, depressing a well-fitted piston; it then fell between two iron rollers, and was by their rotation transferred to several other subjacent rollers, which had not only a motion round their axes, but an alternating traverse motion (endwise). This system of equalizing rollers terminated in two which applied the ink to the types. (See *fig.* 915.) This plan of inking evidently involved a rather complex mechanism, was hence difficult to manage, and sometimes required two hours to get into good working trim. It has been superseded by a happy invention of Mr. Cowper, to be presently described.

915

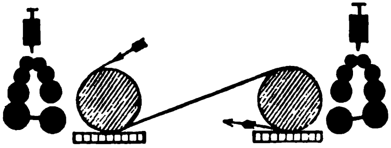


Konig's single, for one side of the sheet.

In order to obtain a great many impressions rapidly from the same form, a paper-conducting cylinder (one embraced by the paper) was mounted upon each side of the inking apparatus, the form being made to traverse under both of them. This double-action machine threw off 1100 impressions per hour when first finished; and by a subsequent improvement, no less than 1800.

Mr. König's next feat was the construction of a machine for printing both sides of the newspaper at each complete traverse of the forms. This resembled two single machines, placed with their cylinders towards each other, at a distance of two or three feet; the sheet was conveyed from one paper cylinder to another, as before, by means of tapes; the track of the sheet exactly resembled the letter S laid horizontally, thus, ∞; and the sheet was turned over or reversed in the course of its passage. At the first paper cylinder it received the impression from the first form, and at the second it received it from the second form; whereby the machine could print 750 sheets of book letter-press on both sides in an hour. This new register apparatus was erected for Mr. T. Bensley, in the year 1815, being the only machine made by Mr. König for printing upon both sides. See *fig.* 916.

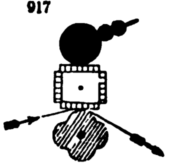
916



Konig's double, for both sides of the sheet.

Messrs. Donkin and Bacon had for some years previous to this date been busily engaged with printing machines, and had indeed, in 1813, obtained a patent for an apparatus, in which the types were placed upon the sides of a revolving prism; the ink was applied by a roller, which rose and fell with the eccentricities of the prismatic surface, and the sheet was wrapped upon another prism fashioned so as to coincide with the eccentricities of the type prism. One such machine was erected for the University of Cambridge. (See *fig.* 917.) It was a beautiful specimen of ingenious contrivance and good workmanship. Though it was found to be too complicated for common operatives, and defective in the mechanism of the inking process; yet it exhibited for the first time the elastic inking rollers, composed of glue combined with treacle, which alone constitute one of the finest inventions of modern typography. In König's machine the rollers were of metal covered with leather, and never answered their purpose very well.

917



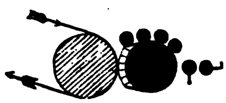
Donkin and Bacon's for type.

Before proceeding further, I may state that the above elastic composition, which resembles caoutchouc not a little, but is not so firm, is made by dissolving with heat in two pounds of ordinary treacle, one pound of good glue, previously soaked during a night in cold water.

In the year 1815, Mr. Cowper turned his scientific and inventive mind to the subject of printing machines, and has since, in co-operation with his partner, Mr. Applegath, carried them to an unlooked-for degree of perfection. In 1815 Mr. Cowper obtained a patent for curving stereotype plates, for the purpose of fixing them on a cylinder

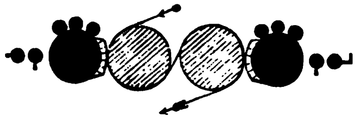
Several machines so mounted, capable of printing 1000 sheets per hour upon both sides, are at work at the present day; twelve machines on this principle having been made for the Directors of the Bank of England a short time previous to their re-issuing gold. See *figs.* 918, and 919.

918



Cowper's single, for curved stereotype.

919



Cowper's double, for both sides of the sheet.

It deserves to be remarked here, that the same object seems to have occupied the attention of Nicholson, Donkin, Bacon, and Cowper; viz., the revolution of the form of types. Nicholson sought to effect this by giving to the shank of a type a shape like the stone of an arch; Donkin and Bacon by attaching types to the sides of a revolving prism; and Cowper, more successfully, by curving a stereotype plate. (See *fig.* 918.) In these machines Mr. Cowper places two paper cylinders side by side, and against each of them a cylinder for holding the plates; each of these four cylinders is about two feet in diameter. Upon the surface of the stereotype-plate cylinder, four or five inking rollers of about three inches in diameter are placed; they are kept in their position by a frame at each end of the said cylinder, and the axles of the rollers rest in vertical slots of the frame, whereby, having perfect freedom of motion, they act by their gravity alone, and require no adjustment.

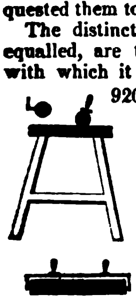
The frame which supports the inking rollers, called the waving-frame, is attached by hinges to the general framework of the machine; the edge of the stereotype-plate cylinder is indented, and rubs against the waving-frame, causing it to vibrate to and fro, and consequently to carry the inking rollers with it, so as to give them an unceasing traverse movement. These rollers distribute the ink over three fourths of the surface of the cylinder, the other quarter being occupied by the curved stereotype plates. The ink is contained in a trough, which stands parallel to the said cylinder, and is formed by a metal roller revolving against the edge of a plate of iron; in its revolution it gets covered with a thin film of ink, which is conveyed to the plate cylinder by a distributing roller vibrating between both. The ink is diffused upon the plate cylinder as before described; the plates in passing under the inking rollers become charged with the colored varnish; and as the cylinder continues to revolve, the plates come into contact with a sheet of paper on the first paper cylinder, which is then carried by means of tapes to the second paper cylinder, where it receives an impression upon its opposite side from the plates upon the second cylinder.

Thus the printing of the sheet is completed. Though the above machine be applicable only to stereotype plates, it has been of general importance, because it formed the foundation of the future success of Messrs. Cowper and Applegath's printing machinery, by showing them the best method of serving out, distributing, and applying the colored varnish to the types.

In order to adapt this method of inking to a flat type-form machine, it was merely requisite to do the same thing upon an extended flat surface or table, which had been performed upon an extended cylindrical surface. Accordingly, Messrs. Cowper and Applegath constructed a machine for printing both sides of the sheets from type, including the inking apparatus, and the mode of conveying the sheet from the one paper cylinder to the other, by means of drums and tapes. It is highly creditable to the scientific judgment of these patentees, that in new modelling the printing machine they dispensed with forty wheels, which existed in Mr. König's apparatus, when Mr. Bensley requested them to apply their improvements to it

The distinctive advantages of these machines, and which have not hitherto been equalled, are the uniform distribution of the ink, the equality as well as delicacy with which it is laid upon the types, the diminution in its expenditure, amounting to one half upon a given quantity of letter-press, and the facility with which the whole mechanism is managed. The band inking-roller and distributing-table, now so common in every printing-office in Europe and America, is the invention of Mr. Cowper, and was specified in his patent. The vast superiority of the inking apparatus in his machines, over the balls used of old, induced him to apply it forthwith to the common press, and most successfully for the public; but with little or no profit to the inventor, as the plan was unceremoniously infringed throughout the kingdom, by such a multitude of printers, whether rich or poor, as to render all attempts at reclaiming his rights by prosecution hopeless. See *fig.* 920.

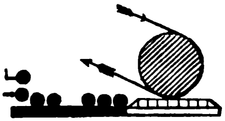
920



Cowper's inking table and roller.

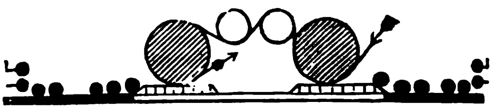
To construct a printing machine which shall throw off two sides at a time with exact register, that is, with the second side placed precisely upon the back of the first, is a very difficult problem, which was first practically solved by Messrs. Applegath and Cowper. It is comparatively easy to make a machine which shall print the one side of a sheet of paper first, and then the other side, by the removal of one form, and the introduction of another; and thus far did Mr. König advance. A correct register requires the sheet, after it has received its first impression from one cylinder, to travel round the peripheries of the cylinders and drums, at such a rate as to meet the types of the second side at the exact point which will ensure this side falling with geometrical nicety upon the back of the first. For this purpose, the cylinders and drums must revolve at the very same speed as the carriage underneath; hence the least incorrectness in the workmanship will produce such defective typography as will not be endured in book-printing at the present day, though it may be tolerated in newspapers. An equable distribution of the ink is of no less importance to beautiful letter-press. See *figs*. 921, 922.

921



Applegath and Cowper's single.

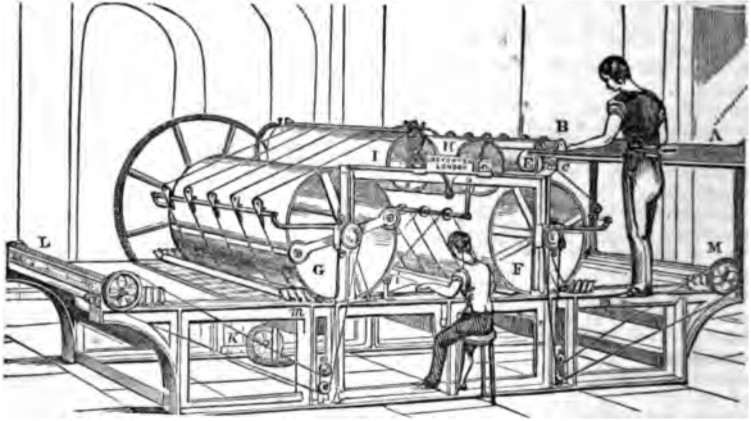
922



Applegath and Cowper's double.

The machines represented in *figs*. 923, 924, 925, are different forms of those which have been patented by Messrs. Applegath and Cowper. That shown in *figs*. 923 and 925, prints both sides of the sheet during its passage, and is capable of throwing off nearly 1000 finished sheets per hour. The moistened quires of blank paper being piled upon a table A, the boy, who stands on the adjoining platform, takes up one sheet after another, and lays them upon the feeder B, which has several linen girths passing across its surface, and round a pulley at each end of the feeder; so that whenever the pulleys begin to revolve, the motion of the girths carries forward the sheet, and delivers it over the entering roller E, where it is embraced between two series of endless tapes, that pass round a series of tension rollers. These tapes are so placed as to fall partly between, and partly exterior to, the pages of the printing; whereby they remain in close contact with the sheet of paper on both of its sides during its progress through the machine. The paper is thus conducted from the first printing cylinder F, to the second cylinder G, without having the truth of its register impaired, so that the coincidence of the two pages is perfect. These two great cylinders, or drums, are made of cast iron, turned perfectly true upon a self-acting lathe;* they are clothed in these parts, corresponding to the typographic impression, with fine woollen cloth, called *blankets* by the pressmen, and revolve upon powerful shafts which rest in brass bearings of the strong framing of the machine. These bearings, or plummer blocks, are susceptible of any degree of adjustment, by set screws. The drums H and I are made of wood; they serve to conduct the sheet evenly from the one printing cylinder to the other.

923



One series of tapes commences at the upper part of the entering drum E, proceeds in contact with the right-hand side and under surface of the printing cylinder F, passes next over the carrier-drum H, and under the carrier-drum I; then encompassing the left-hand side and under portion of the printing drum G, it passes in contact with the small tension rollers *a*, *b*, *c*, *d*, *fig.* 925, and finally arrives at the roller E, which may be called the commencement of the one series of endless tapes. The other series may be supposed to commence at the roller *h*; it has an equal number of tapes, and corresponds with the former in being placed upon the cylinders so that the sheets of paper may be held securely between them. The second series descends from the roller *h*, *fig.* 925, to the entering drum E, where it meets and coincides with the first series in such a way that both sets of tapes proceed together *under* the printing cylinder F, *over* H, *under* I, and *round* G, until they arrive at the roller *i*, *fig.* 923, where they separate, after having continued in contact, except at the places where the sheets of paper are held between them. The tapes descend from the roller *i*, to a roller at *k*, and, after passing in contact with rollers at *l*, *m*, *n*, they finally arrive at the roller *h*, where they were supposed to commence. Hence two series of tapes act invariably in contact, without the least mutual interference, as may be seen by inspection of the *figs.* 923, 924, 925.

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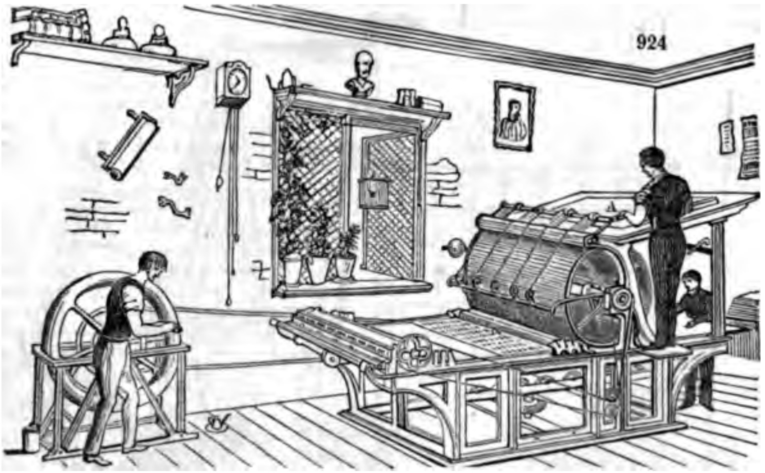
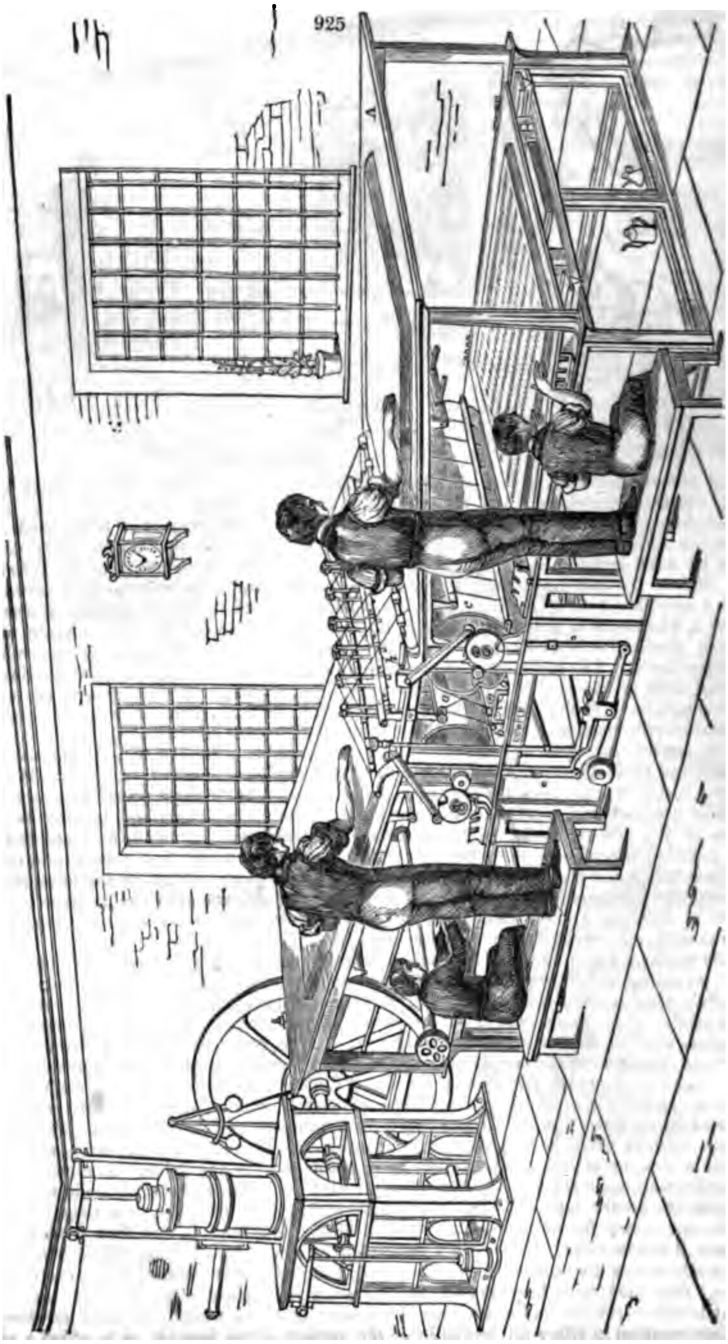
* I have witnessed with much pleasure the turning of these great cylinders in Messrs. Cowper's factory at Manchester.


924

The various cylinders and drums revolve very truly by means of a system of toothed wheels and pinions mounted at their ends. Two horizontal forms of types are laid at a certain distance apart upon the long carriage M, adjoining to each of which there is a flat metallic plate, or inking table, in the same plane. The common carriage, bearing its two forms of type and two inking tables, is moved backwards and forwards, from one end of the printing machine to the other, upon rollers attached to the frame-work, and in its traverse brings the types into contact with the sheet of paper clasped by the tapes round the surfaces of the printing cylinders. This alternate movement of the carriage is produced by a pinion working alternately into the opposite sides of a rack under the table. The pinion is driven by the bevel wheels K.

The mechanism for supplying the ink, and distributing it over the forms, is one of the most ingenious and valuable inventions belonging to this incomparable machine, and is so nicely adjusted, that a single grain of the pigment may suffice for printing one side of a sheet. Two similar sets of inking apparatus are provided; one at each end of the machine, adapted to ink its own form of type. The metal roller L, called the *ductor* roller, as it draws out the supply of ink, has a slow rotatory motion communicated to it by a catgut cord, which passes round a small pulley upon the end of the shaft of the printing cylinder G. A horizontal plate of metal, with a straight-ground edge, is adjusted by set screws, so as to stand nearly in contact with the ductor roller. This plate has an upright ledge behind, converting it into a sort of trough or magazine, ready to impart a coating of ink to the roller, as it revolves over the table. Another roller, covered with elastic composition (see *suprà*), called the vibrating roller, is made to travel between the ductor roller and the inking table; the vibrating roller, as it rises, touches the ductor roller for an instant, abstracts a film of ink from it, and then descends to transfer it to the table. There are 3 or 4 small rollers of distribution, placed somewhat diagonally across the table at M, (inclined only 2 inches from a parallel to the end of the frame,) furnished with long slender axles, resting in vertical slots, whereby they are left at liberty to revolve and to traverse at the same time; by which compound movement they are enabled to efface all inequality in the surface of the varnish, or to effect a perfect distribution of the ink along the table. The table thus evenly smeared, being made to pass under the 3 or 4 proper inking rollers N, *fig.* 924, imparts to them a uniform

925



film of ink, to be immediately transferred by them to the types. Hence each time that the forms make a complete traverse to and fro, which is requisite for the printing of every sheet, they are touched no less than eight times by the inking rollers. Both the distributing and inking rollers turn in slots, which permit them to rise and fall so as to bear with their whole weight upon the inking table and the form, whereby they never stand in need of any adjustment by screws, but are always ready for work when dropped into their respective places.

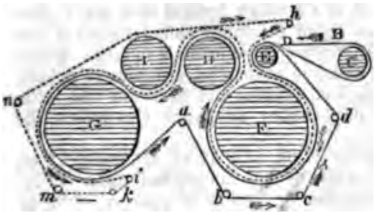
Motion is given to the whole system of apparatus by a strap from a steam engine going round a pulley placed at the end of the axle at the back of the frame; one steam-horse power being adequate to drive two double printing machines; while a single machine may be driven by the power of two men acting upon a fly-wheel. In Messrs. Clowes' establishment, in Stamford-street, two five-horse engines actuate nineteen of the above described machines.

The operation of printing is performed as follows:—See *fig.* 926.

The sheets being carefully laid, one by one, upon the linen girths, at the feeder B, the rollers C and D are made to move, by means of a segment wheel, through a portion of a revolution. This movement carries on the sheet of paper sufficiently to introduce it between the two series of endless tapes at the point where they meet each other upon the entering drum E. As soon as the sheet is fairly embraced between the tapes, the rollers C and D are drawn back, by the operation of a weight, to their original position, so as to be ready to introduce another sheet into the machine. The sheet, advancing between the endless tapes, applies itself to the blanket upon the printing cylinder F, and as it revolves meets the first form of types, and receives their impression; after being thus printed on one side, it is carried, over H and under I, to the blanket upon the printing cylinder G, where it is placed in an inverted position; the printed side being now in contact with the blanket, and the white side being outwards, meets the second form of types at the proper instant, so as to receive the second impression, and get completely printed. The perfect sheet, on arriving at the point *i*, where the two series of tapes separate, is tossed out by centrifugal force into the hands of a boy.

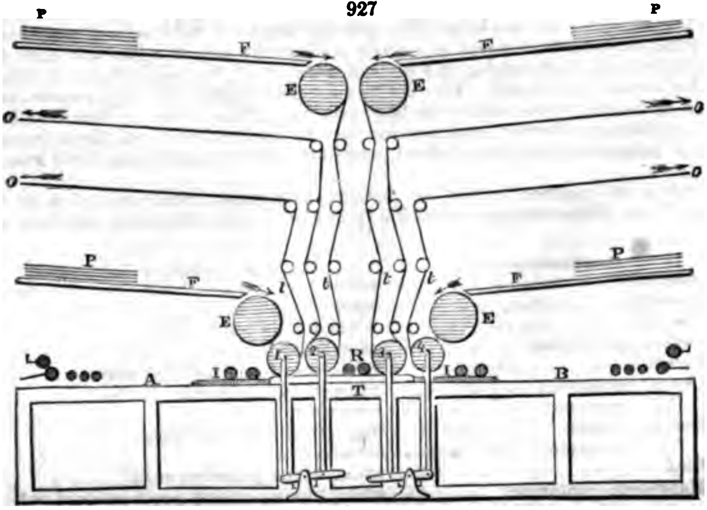
The diagram, *fig.* 926, shows the arrangement of the tapes, agreeably to the preceding description; the feeder B, with the rollers C and D, is seento have an independent endless girth.

926



The diagram, *fig.* 927, explains the structure of the great machine contrived by Messrs. Applegath and Cowper for printing the *Times* newspaper. Here there are four places to lay on the sheets, and four to take them off; consequently, the assistance of eight lads is required. P, P, P, P, are the four piles of paper; F, F, F, F, are the four feeding-boards; E, E, E, E, are the four entering drums, upon which the sheets are introduced between the tapes *t*, *t*, *t*, *t*, whence they are conducted to the

927



four printing cylinders 1, 2, 3, 4; T is the form of type; I, I, are two inking tables, of which one is placed at each end of the form. The inking apparatus is similar to that above described, with the addition of two central inking rollers R, which likewise receive their ink from the inking tables. The printing cylinders 1, 2, 3, 4, are made to rise and fall about half an inch; the first and third simultaneously, as also the second and fourth. The form of type, in passing from A to B, prints sheets at 1 and 3; in returning from B to A, it prints sheets at 4 and 2; while the cylinder alternately falls to give the impression, and rises to permit the form to pass untouched.

Each of the lines marked *t*, consists of two endless tapes, which run in contact at the parts shown, but separate at the entering drums E, and at the taking off parts *o*, *o*, *o*, *o*. The return of the tapes to the entering drum is omitted in the diagram, to avoid confusion of the lines.

The sheets of paper being laid upon their respective feeding-boards, with the fore edges just in contact with the entering drum, a small roller, called the drop-down roller, falls, at proper intervals, down upon the edges of the sheets; the drum and the roller being then removed, instantly carry on the sheet, between the tapes *t*, downwards to the printing cylinder, and thence upwards to *o*, *o*, *o*, *o*, where the tapes are parted, and the sheet falls into the hands of the attendant boy. This noble mechanism is so perfectly equipped, that it is generally in full work within four minutes after the form is brought into the machine-room. The speed of König's machine, by which the *Times* was formerly printed, was such as to turn out 1800 papers per hour; that of Applegath and Cowper throws off 4200 per hour, and it has been daily in use during eight years.

PRUSSIAN BLUE, and PRUSSIATE OF POTASH, are two important articles of chemical manufacture, which must be considered together. The first is called by English chemists, *Ferrocyanodide of iron, the Cyanure ferroso-ferrique* of Berzelius; *Eisenblausaures eisenoxyd*, or *eisencyanür* + *eisencyanid*, Germ.; the second is called *Ferrocyanodide of potassium*, the *Cyanure ferroso-potassique* of Berzelius; *Eisencyanur-kalium, cyaneisen* + *cyankalium* or *Blausaures eisenoxydul-kali*, Germ.

Prussian blue (*Berliner-blau*, Germ.), is a chemical compound of iron and cyanogen. When organic matters, abounding in nitrogen, as dried blood, horns, hair, skins, or hoofs of animals, are triturated along with potash in a strongly ignited iron pot, a dark gray mass is obtained, that affords to water the liquor originally called *lixivium sanguinis*, or blood-ley, which, by evaporation, yields lemon-colored crystals in large rectangular tables, bevelled at the edges. This salt is called in commerce, prussiate of potash, and has for its ultimate constituents, potassium, iron, oxygen, and hydrogen (the latter two in such proportions as to form water), and the peculiar compound CYANOGEN, the *blaustoff* of the Germans.

These crystals consist, in 100 parts, of potassium 37·02, iron 12·82, cyanogen 37·40, water 12·76; or, cyanide of potassium 61·96, cyanide of iron 25·28, and water 12·76. They may be represented also by the following composition: 44·58 of potassa, 38·82 of hydrocyanic or prussic acid, and 16·60 of oxyde of iron, in 100 parts; but the first appears to be their true chemical constitution. Dry ferrocyanodide of potassium is a compound of one atom of cyanide of iron, 54 = (28 + 26), and 2 atoms of cyanide of potassium, 132, = (26 × 2 + 40 × 2); the sum being 186; hydrogen being 1·0 in the scale of equivalents. The crystals of prussiate of potash are nearly transparent, soft, of a sweetish saline and somewhat bitterish taste, soluble in 4 parts of water at 52° F., and in 1 part of boiling water, but insoluble in alcohol. They are permanent in the air at ordinary temperatures, but in a moderately warm stove-room they part with 12¾ per cent. of water, without losing their form or coherence, and becomes thereby a white friable anhydrous ferrocyanodide of potassium, consisting of 42·44 potassium, 42·87 cyanogen, and 14·69 iron, in 100 parts.

This salt is an excellent reagent for distinguishing metals from each other, as the following TABLE of the precipitates which it throws down from their saline solutions will show:—

Metallic solutions.	Color of precipitate.
Antimony - - - - - -	white.
Bismuth - - - - - -	white.
Cadmium - - - - - -	white, a little yellowish.
Cerium (protoxyde) - - -	white, soluble in acids.
Cobalt - - - - - -	green, soon turning reddish-gray.
Copper (protoxyde) - - - -	white, changing to red.
Do. (peroxyde) - - - -	brown-red.
Iron (protoxyde) - - - -	white, rapidly turning blue.
Do. (peroxyde) - - -	dark blue.
Lead - - - - - -	white, with a yellowish cast.
Manganese (protoxyde) - -	white, turning quickly peach or blood-red.

Metallic solutions.	Colors of precipitate.
Manganese (deutoxyde)	greenish-gray.
Mercury (protoxyde)	white.
Do. (peroxyde)	white, turning blue.
Molybdenum	dark brown.
Nickel (oxyde)	white, turning greenish.
Palladium (protoxyde)	green (gelatinous.)
Silver	white, turning brown in the light.
Tantalum	yellow, dark burned color.
Tin (protoxyde)	white, (gelatinous.)
Do. (peroxyde)	yellow, do.
Uranium	red-brown.
Zinc	white.

No precipitations ensue with solutions of the alkaline or earthy salts, except that of yttria, which is white; nor with those of gold, platinum, rhodium, iridium, osmium, (in concentrated solutions) tellurium, chromium, tungstenium. All the precipitates by the ferrocyanodide of iron, are double compounds of cyanide of iron with cyanide of the metal thrown down, which is produced by the reciprocal decomposition of the cyanide of potassium and the peculiar metallic oxyde present in the solution. The precipitate from the sulphate of copper has a fine brown color, and has been used as a pigment; but it is somewhat transparent, and therefore does not cover well. The precipitate from the peroxyde salts of iron is a very intense Prussian blue, called on the continent, Paris blue. It may be regarded as a compound of prussiate of protoxyde and prussiate of peroxyde of iron; or as a double cyanide of the protoxyde and peroxyde of iron, as the denomination *cyanure ferroso-ferrique* denotes. In numbers, its composition may be therefore stated thus: prussic or hydrocyanic acid, 48·48; protoxyde of iron, 20·73; peroxyde of iron, 30·79; or cyanogen, 46·71; iron, 37·36; water, 15·93; which represent its constitution when it is formed by precipitation with the prussiate of potash or a salt of iron that contains no protoxyde. If the iron be but partially peroxydized in the salt, it will afford a precipitate, at first pale blue, which turns dark blue in the air, consisting of a mixture of prussiate of protoxyde and prussiate of peroxyde. In fact, the white cyanide of iron (the prussiate of the pure protoxyde), when exposed to the air in a moist condition, becomes, as above stated, dark blue; yet the new combination formed in this case through absorption of oxygen, is essentially different from that resulting from the precipitation by the peroxyde of iron, since it contains an excess of the peroxyde in addition to the usual two cyanides of iron. It has been therefore called *basic* Prussian blue, and, from its dissolving in pure water, *soluble* Prussian blue.

Both kinds of Prussian blue agree in being void of taste and smell, in attracting humidity from the air when they are artificially dried, and being decomposed at a heat above 348° F. The neutral or insoluble Prussian blue is not affected by alcohol; the basic, when dissolved in water, is not precipitated by that liquid. Neither is acted upon by dilute acids; but they form with concentrated sulphuric acid a white pasty mass, from which they are again reproduced by the action of cold water. They are decomposed by strong sulphuric acid at a boiling heat, and by strong nitric acid at common temperatures; but they are hardly affected by the muriatic. They become green with chlorine, but resume their blue color when treated with disoxydizing reagents. When Prussian blue is digested in warm water along with potash, soda, or lime, peroxyde of iron is separated, and a ferroprussiate of potash, soda, or lime remains in solution. If the Prussian blue has been previously purified by boiling in dilute muriatic acid, and washing with water, it will afford by this treatment a solution of ferrocyanodide of potassium, from which by evaporation this salt may be obtained in its purest crystalline state. When the powdered Prussian blue is diffused in boiling water, and digested with red oxyde of mercury, it parts with all its oxyde of iron, and forms a solution of bi-cyanodide, improperly called prussiate of mercury; consisting of 79·33 mercury, and 20·67 cyanogen; or, upon the hydrogen equivalent scale, of 200 mercury, and $52=(26\times2)$ cyanogen. When this salt is gently ignited, it affords gaseous cyanogen. Hydrocyanic or prussic acid, which consists of 1 atom of cyanogen $= 26, + 1$ of hydrogen $= 1$, is prepared by distilling the mercurial bi-cyanide in a glass retort with the saturating quantity of dilute muriatic acid. Prussic acid may also be obtained by precipitating the mercury by sulphureted hydrogen gas from the solution of its cyanide; as also by distilling the ferrocyanide of potassium along with dilute sulphuric acid. Prussic acid is a very volatile light fluid, eminently poisonous, and is spontaneously decomposed by keeping, especially when somewhat concentrated.

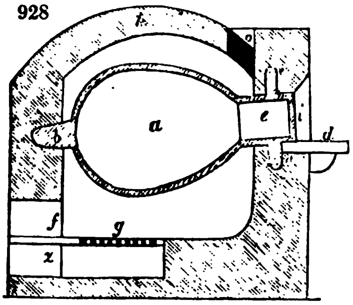
Having expounded the chemical constitution of Prussian blue and prussiate of potash, I shall now treat of their *manufacture upon the commercial scale*.

1. *Of blood-ley*, the phlogisticated alkali of Scheele. Among the animal substances used for the preparation of this lixivium, blood deserves the preference, where it can be had cheap *enough. It must be* evaporated to perfect dryness, reduced to powder, and sifted.

Hoofs, parings of horns, hides, old woollen rags, and other animal offals, are, however, generally had recourse to, as condensing most azotized matter in the smallest bulk. Dried funguses have been also prescribed. These animal matters may either be first carbonized in cast iron cylinders, as for the manufacture of *sal ammoniac* (which see), and the residual charcoal may be then taken for making the ferroprussiate; or the dry animal matters may be directly employed. The latter process is apt to be exceedingly offensive to the workmen and neighborhood, from the nauseous vapors that are exhaled in it. Eight pounds of horn (hoofs), or ten pounds of dry blood, afford upon an average one pound of charcoal. This must be mixed well with good pearlash, (freed previously from most of the sulphate of potassa, with which it is always contaminated), either in the dry way, or by soaking the bruised charcoal with a strong solution of the alkali; the proportion being one part of carbonate of potassa to from 1½ to 2 parts of charcoal, or to about eight parts of hard animal matter. Gautier has proposed to calcine three parts of dry blood with one of nitre; with what advantage to the manufacturer, I cannot discover.

The pot for calcining the mixture of animal and alkaline matter is egg-shaped as represented at *a*, *fig*. 928, and is considerably narrowed at the neck *e*, to facilitate the closing of the mouth with a lid *i*. It is made of cast iron, about two inches thick in the belly and bottom; this strength being requisite because the chemical action of the materials wears the metal fast away. It should be built into the furnace in a direction sloping downwards, (more than is shown in the figure), and have a strong knob *b*, projecting from its bottom to support it upon the back wall, while its shoulder is embraced at the arms *c*, *c*, by the brickwork in front. The interior of the furnace is so formed as to leave but a space of a few inches round the pot, in order to make the flame play closely over its whole surface. The fire-door *f*, and the draught-hole *z*, of the ash-pit, are placed in the posterior part of the furnace, in order that the workmen may not be incommoded by the heat. The smoke vent *o*, issues through the arched top *h* of the furnace, towards the front, and is thence led backwards by a flue to the main chimney of the factory. *d* is an iron or stone shelf, inserted before the mouth of the pot, to prevent loss in shovelling out the semi-liquid paste. The pot may be half filled with the materials.

928



The calcining process is different, according as the animal substances are fresh or carbonized. In the first case, the pot must remain open, to allow of diligent stirring of its contents, with a slightly bent flat iron bar or scoop, and of introducing more of the mixture as the intumescence subsides, during a period of five or six hours, till the nauseous vapors cease to rise, till the flame becomes smaller and brighter, and till a smell of ammonia be perceived. At this time, the heat should be increased, the mouth of the pot should be shut, and opened only once every half hour, for the purpose of working the mass with the iron paddle. When on opening the mouth of the pot, and stirring the pasty mixture, no more flame rises, the process is finished.

If the animal ingredients are employed in a carbonized state, the pot must be shut as soon as its contents are brought to ignition by a briskly urged fire, and opened for a few seconds only every quarter of an hour, during the action of stirring. At first, a body of flame bursts forth every time that the lid is removed; but by degrees this ceases, and the mixture soon agglomerates, and then softens into a paste. Though the fire be steadily kept up, the flame becomes less and less each time that the pot is opened; and when it ceases, the process is at an end. The operation, with a mass of 50 pounds of charcoal and 50 pounds of purified pearlash, lasts about 12 hours, the first time that the furnace is kindled; but when the pot has been previously brought to a state of ignition, it takes only 7 or 8 hours. In a well-appointed factory, the fire should be invariably maintained at the proper pitch, and the pots should be worked with relays of operatives.

The molten mass is now to be scooped out with an appropriate iron shovel, having a long shank, and caused to cool in small portions, as quickly as possible; but not by throwing it into water, as has sometimes been prescribed; for in this way a good deal of the cyanogen is converted into ammonia. If it be heaped up and kept hot in contact with air, some of the ferrocyanide is also decomposed, with diminution of the product. The crude mass is to be then put into a pan with cold water, dissolved by the application of a moderate heat, and filtered through cloths. The charcoal which remains upon the filter possesses the properties of decoloring sirups, vinegars, &c., and of destroying smells in a pre-eminent degree. It may also serve, when mixed with fresh animal coal, for another calcining operation.

As the iron requisite for the formation of the ferrocyanide is in general derived from the sides of the pot, this is apt to wear out into holes, especially at its under side, where the heat is greatest. In this event, it may be taken out of the furnace, patched up with iron-rust cement, and re-inserted with the sound side undermost. The erosion of the pot may be obviated in some measure by mixing iron borings or cinder (hammerschlag) with the other materials, to the amount of one or two hundredths of the potash.

The above lixivium is nót a solution of pure ferroprussiate; it contains not a little cyanide of potassium, which in the course of the process had not absorbed the proper dose of iron to form a ferrocyanide; it contains also more or less carbonate of potash, with phosphate, sulphate, hydrogenated sulphuret, muriate, and sulpho-cyanide of the same base, as well as phosphate of lime; substances derived partly from the impure potash, and partly from the incinerated animal matters. Formerly that very complex impure solution was employed directly for the precipitation of Prussian blue; but now, in all well regulated works, it is converted by evaporation and cooling into crystallized ferroprussiate of potash. The mother-water is again evaporated and crystallized, whereby a somewhat inferior ferroprussiate is obtained. Before evaporating the ley, however, it is advisable to add as much solution of green sulphate of iron to it, as will re-dissolve the white precipitate of cyanide of iron which first falls, and thereby convert the cyanide of potassium, which is present in the liquor, into ferrocyanide of potassium. The commercial prussiate of potash may be rendered chemically pure by making its crystals effloresce in a stove, fusing them with a gentle heat in a glass retort, dissolving the mass in water, neutralizing any carbonate and cyanide of potash that may be present with acetic acid, then precipitating the ferroprussiate of potash by the addition of a sufficient quantity of alcohol, and finally crystallizing the precipitated salt twice over in water. The sulphate of potassa may be decomposed by acetate of baryta, and the resulting acetate of potassa removed by alcohol.

2. *The precipitation of Prussian blue.*—Green sulphate of iron is always employed by the manufacturer, on account of its cheapness, for mixing with solution of the ferroprussiate, in forming Prussian blue, though the red sulphate, nitrate, or muriate of iron would afford a much richer blue pigment. Whatever salt of iron be preferred, should be carefully freed from any cupreous impregnation, as this would give the pure blue a dirty brownish cast. The green sulphate of iron is the most advantageous precipitant, on account of its affording protoxyde, tó convert into ferrocyanide any cyanide of potassium that may happen to be present in the uncrystallized lixivium. The carbonate of potash in that lixivium might be saturated with sulphuric acid before adding the solution of sulphate of iron; but it is more commonly done by adding a certain portion of alum; in which case, alumina falls along with the Prussian blue; and though it renders it somewhat paler, yet it proportionally increases its weight; whilst the acid of the alum saturates the carbonate of potash, and prevents its throwing down iron-oxyde, to degrade by its brown-red tint the tone of the blue. For every pound of pearlash used in the calcination, from two to three pounds of alum are employed in the precipitation. When a rich blue is wished for, the free alkali in the Prussian ley may be partly saturated with sulphuric acid, before adding the mingled solutions of copperas and alum. One part of the sulphate of iron is generally allowed for 15 or 20 parts of dried blood, and 2 or 3 of horn-shavings or hoofs. But the proportion will depend very much upon the manipulations, which, if skilfully conducted, will produce more of the cyanides of iron, and require more copperas to neutralize them. The mixed solutions of alum and copperas should be progressively added to the ley as long as they produce any precipitate. This is not at first a fine blue, but a greenish gray, in consequence of the admixture of some white cyanide of iron; it becomes gradually blue by the absorption of oxygen from the air, which is favored by agitation of the liquor. Whenever the color seems to be as beautiful as it is likely to become, the liquor is to be run off by a spigot or cock from the bottom of the precipitation vats, into flat cisterns, to settle. The clear supernatant fluid, which is chiefly a solution of sulphate of potash, is then drawn off by a syphon; more water is run on with agitation to wash it, which after settling is again drawn off; and whenever the washings become tasteless, the sediment is thrown upon filter sieves, and exposed to dry, first in the air of a stove, but finally upon slabs of chalk or Paris plaster. But for several purposes, Prussian blue may be best employed in the fresh pasty state, as it then spreads more evenly over paper and other surfaces.

A good article is known by the following tests: it feels light in the hand, adheres to the tongue, has a dark lively blue color, and gives a smooth deep trace; it should not effervesce with acids, as when adulterated with chalk; nor become pasty with boiling water, as when adulterated with starch. The Paris blue, prepared without alum, with a peroxyde salt of iron, displays, when rubbed, a copper-red lustre, like indigo. Prussian blue, degraded in its color by an admixture of free oxyde of iron, may be improved by digestion in dilute sulphuric or muriatic acid, washing, and drying. Its relative richness in the real ferroprussiate of iron may be estimated by the quantity of potash or soda which a given quantity of it requires to destroy its blue color.

Sulphureted hydrogen passed through Prussian blue diffused in water, whitens it; while prussic acid is eliminated, sulphur is thrown down, and the sesquicyanide of iron is converted into the single cyanide. Iron and tin operate in the same way. When Prussian blue is made with two atoms of ferrocyanide of potassium, instead of one, it becomes soluble in water.

For the mode of applying this pigment in dyeing, see CALICO-PRINTING.

Sesquiferrocyanate of potash is prepared by passing chlorine gas through a solution of ferrocyanide of potassium, till it becomes red, and ceases to precipitate the peroxyde salts of iron. The liquor yields, by evaporation, prismatic crystals, of a ruby-red transparency. They are soluble in 38 parts of water, and consist of 40·42 parts of sesquicyanide of iron, and 59·58 of cyanide of potassium. The solution of this salt precipitates the following metals, as stated in the table:—

Bismuth - -	pale yellow.	Mercury (peroxyde) -	yellow.
Cadmium - -	yellow.	Molybdenum - -	red-brown.
Cobalt - -	dark brown-red.	Nickel - - -	yellow-green.
Copper (protoxyde)	red-brown.	Silver - - -	red-brown.
Do. (peroxyde)	yellow-green.	Tin (protoxyde) -	white.
Iron, protoxyde salts of	blue.	Uranium - - -	red-brown.
Manganese - -	brown.	Zinc - - -	orange-yellow.
Mercury (protoxyde)	red-brown.		

PUMICE-STONE (*Pierre-ponce*, Fr.; *Bimstein*, Germ.), is a spongy, vitreous-looking mineral, consisting of fibres of a silky lustre, interlaced with each other in all directions. It floats upon water, is harsh to the touch, having in mass a mean sp. grav. of 0·914; though brittle, it is hard enough to scratch glass and most metals. Its color is usually grayish white; but it is sometimes bluish, greenish, reddish, or brownish. It fuses without addition at the blowpipe into a white enamel. According to Klaproth, it is composed of, silica, 77·5; alumina, 17·5; oxyde of iron, 2; potassa and soda, 3; in 100 parts. The acids have hardly any action upon pumice-stone. It is used for polishing ivory, wood, marble, metals, glass, &c.; as also skins and parchment. Pumice-stone is usually reckoned to be a volcanic product, resulting, probably, from the action of fire upon obsidians. The chief localities of this mineral are the islands of Lipari, Ponza, Ischia, and Vulcano. It is also found in the neighborhood of Andernach, upon the banks of the Rhine, in Teneriffe, Iceland, Auvergne, &c. It is sometimes so spongy as to be of specific gravity 0·37.

PUOZZOLANA is a volcanic gravelly product, used in making hydraulic mortar. See CEMENTS and MORTARS.

PURPLE OF CASSIUS. *Gold purple* (*Pourpre de Cassius*, Fr.; *Gold-purpur*, Germ.), is a vitrifiable pigment, which stains glass and porcelain of a beautiful red or purple hue. Its preparation has been deemed a process of such nicety, as to be liable to fail in the most experienced hands. The following observations will, I hope, place the subject upon a surer footing.

The proper pigment can be obtained only by adding to a neutral muriate of gold a mixture of the protochloride and perchloride of tin. Everything depends upon this intermediate state of the tin; for the protochloride does not afford, even with a concentrated solution of gold, either a chestnut-brown, a blue, a green, a metallic precipitate, or one of a purple tone; the perchloride occasions no precipitate whatever, whether the solution of gold be strong or dilute; but a properly neutral mixture, of 1 part of crystallized protochloride of tin, with 2 parts of crystallized perchloride, produces, with 1 part of crystallized chloride of gold (all being in solution), a beautiful purple-colored precipitate. An excess of the protosalt of tin gives a yellow, blue, or green cast; an excess of the persalt gives a red and violet cast; an excess in the gold salt occasions, with heat (but not otherwise), a change from the violet and chestnut-brown precipitate into red. According to Fuchs, a solution of the sesquioxyde of tin in muriatic acid, or of the sesquichloride in water, serves the same purpose, when dropped into a very dilute solution of gold.

Buisson prepares gold-purple in the following way. He dissolves, first, 1 gramme of the best tin in a sufficient quantity of muriatic acid, taking care that the solution is neutral; next, 2 grammes of tin in aqua regia, composed of 3 parts of nitric acid, and 1 part of muriatic, so that the solution can contain no protoxyde; lastly, 7 grammes of fine gold in a mixture of 1 part of nitric acid, and 6 of muriatic, observing to make the solution neutral. This solution of gold being diluted with 3½ litres of water (about three quarts), the solution of the perchloride of tin is to be added at once, and afterwards that of the protochloride, drop by drop, till the precipitate thereby formed acquires the wished-for tone; after which it should be edulcorated by washing, as quickly as possible.

Frick gives the following prescription:—Let tin be set to dissolve in very dilute aqua regia without heat, till the fluid becomes faintly opalescent, when the metal must be taken out, and weighed. The liquor is to be diluted largely with water, and a definite weight of a dilute solution of gold, and dilute sulphuric acid, is to be simultaneously stirred into the nitro-muriate of tin. The quantity of solution of gold to be poured into the tin liquor must be such, that the gold in the one is to the tin in the other in the ratio of 36 to 10.

Gold-purple becomes brighter when it is dry, but appears still as a dirty-brown powder. Muriatic acid takes the tin out of the fresh-made precipitate, and leaves the gold either in the state of metal or of a blue powder. At a temperature between 212° and 300° Fahr., mercury dissolves out all the gold from the ordinary purple of Cassius.

Relative to the constitution of gold-purple, two views are entertained: according to the first, the gold is associated in the metallic state along with the oxyde of tin; according to the second, the gold exists as a purple oxyde along with the sesquioxyde or peroxyde of tin. Its composition is differently reported by different chemists. The constituents, according to—

	Gold.	Tin oxyde
Oberkampf, in the purple precipitate, are	39·82	60·18
violet ditto	20·58	79·12
Berzelius	30·725	69·275
Buisson	30·19	69·81
Gay Lussac	30·89	69·11
Fuchs	17·87	82·13

If to a mixture of protochloride of tin, and perchloride of iron, a properly diluted solution of gold be added, a very beautiful purple precipitate of Cassius will immediately fall, while the iron will be left in the liquid in the state of a protochloride. The purple thus prepared keeps in the air for a long time without alteration. Mercury does not take from it the smallest trace of gold.—*Fuchs' Journal für Chemie*, t. xv.

PURPLE OF MOLLUSCA is a viscid liquor, secreted by certain shell-fish, the *Buccinum lapillus*, and others, which dyes wool, &c. of a purple color, and is supposed to be the substance of the Tyrian dye, so highly prized in ancient Rome for producing the imperial purple. See Dyeing.

PURPURIC ACID is an acid obtained by treating uric or lithic acid with dilute nitric acid. It has a fine purple color; but has hitherto been applied to no use in the arts.

PURPURINE is the name of a coloring principle, supposed by Robiquet and Colin to exist in madder. Its identity is questionable.

PUTREFACTION, *and its Prevention*. The decomposition of animal bodies, or of such plants as contain azote in their composition, which takes place spontaneously when they are exposed to the air, under the influence of moisture and warmth, is called putrefaction. During this process, there is a complete transposition of the proximate principles, the elementary substances combining in new and principally gaseous compounds. Oxygen is absorbed from the atmosphere, and converted into carbonic acid; one portion of the hydrogen forms water with the oxygen; another portion forms, with the azote, the carbon, the phosphorus, and the sulphur respectively, ammonia, carbureted, phosphureted, and sulphureted hydrogen gases, which occasion the nauseous smell evolved by putrefying bodies. There remains a friable earthy-looking residuum, consisting of rotten mould and charcoal. Vegetables which contain no azote, like the ligneous part of plants, suffer their corresponding decomposition much more slowly, and with different modifications, but they are finally converted into vegetable mould. In this process, the juices with which the plants are filled first enter into the acetous fermentation under the action of heat and moisture; the acid thereby generated destroys the cohesion of the fibrous matter, and thus reduces the solids to a pulpy state. In the progress of the decomposition, a substance is lastly produced which resembles oxydized extractive, is soluble in alkalis, and is sometimes called *mould*. This decomposition of the plants which contain no azote, goes on without any offensive smell, as none of the above-named nauseous gases are disengaged. When vegetable matters are mixed with animal, as in the dung of cattle, this decomposition proceeds more rapidly, because the animalized portion serves as a ferment to the vegetable. Vegetable acids, resins, fats, and volatilized oils, are not of themselves subject to putrefaction.

The object of the present article is to detail the principles and processes, according to which, for various purposes in the arts, the destruction of bodies by putrefaction may be prevented, and their preservation in a sound state secured for a longer or a shorter time.

I. CONDITIONS OF THE PREVENTION OF PUTREFACTION.

The circumstances by which putrefaction is counteracted, are, 1. the chemical change of the azotized juices; 2. the abstraction of the water; 3. the lowering of the temperature; and 4. the exclusion of oxygen.

1. *The chemical change of the azotized juices.*—The substance which in dead animal matter is first attacked with putridity, and which serves to communicate it to the solid fibrous parts, is albumen, as it exists combined with more or less water in all the animal fluids and soft parts. In those vegetables also which putrefy, it is the albumen which first suffers decomposition; and hence those plants which contain most of that proximate principle, are most apt to become putrid, and most resemble, in this respect, animal substances; of which fact, mushrooms, cabbages, coleworts, &c., afford illustrations. The albumen, when dissolved in water, very readily putrefies in a moderately warm air; but when coagulated, it seems as little liable to putridity as fibrin itself. By this change, it throws off the superfluous water, becomes solid, and may then be easily dried. Hence, those means which by coagulation make the albumen insoluble, or form with it a new compound, which does not dissolve in water, but which resists putrefaction, are powerful antiseptics. Whenever the albumen is coagulated, the uncombined water may be easily evaporated away, and the residuary solid matter may be readily dried in the air, so as to be rendered unsusceptible of decomposition.

In this way acids operate, which combine with the albumen, and fix it in a coagulated state, without separating it from its solution: such is the effect of vinegar, citric acid, tartaric acid, &c.

Tannin combines with the albuminous and gelatinous parts of animals, and forms insoluble compounds, which resist putrefaction; on which fact the art of tanning is founded.

Alcohol, oil of turpentine, and some other volatile oils, likewise coagulate albumen, and thereby protect it from putrescence. The most remarkable operation of this kind is exhibited by wood vinegar, in consequence of the *creosote* contained in it, according to the discovery of Reichenbach. This peculiar volatile oil has so decided a power of coagulating albumen, that even the minute portion of it present in pyroligneous vinegar is sufficient to preserve animal parts from putrefaction, when they are simply soaked in it. Thus, also, flesh is cured by wood smoke. Wood tar likewise protects animal matter from change, by the creosote it contains. The ordinary pyroligneous acid sometimes contains 5 per cent. of creosote.

In circumstances where a stronger impregnation with this antiseptic oil may be necessary, common wood vinegar may be heated to 167° F., and saturated with effloresced Glauber's salts, by which expedient the oil is separated and made to float upon the surface of the warm liquid; whence it should be immediately skimmed off; because, by cooling and crystallizing, the solution would so diminish in density as to allow the oil to sink to the bottom; for its specific gravity is considerably greater than that of water. This oil, which contains, besides creosote, some other volatile constituents, may be kept dissolved ready for use in strong vinegar or alcohol. Water takes up of pure creosote only 1¼ per cent.; but alcohol dissolves it in every proportion.

The earthy and metallic salts afford likewise powerful means for separating albumen from its watery solution, their bases having the property of forming insoluble compounds with it. The more completely they produce this separation, the more effectually do they counteract putrefaction. The alkaline salts also, as common salt, sal ammoniac, saltpetre, and tartar, operate against putrescence, though in a smaller degree, because they do not precipitate the albumen; but, by abstracting a part of its water, they render it less liable to become putrid. Among the earthy salts, alum is the most energetic, as it forms a subsalt which combines with albumen; it is three times more antiseptic than common salt, and from seven to eight times more so than saltpetre. Muriate of soda, however, may be employed along with alum, as is done in the tawing of sheepskins.

The metallic salts operate still more effectually as antiseptics, because they form with albumen still more intimate combinations. Under this head we class the green and red sulphates of iron, the chloride of zinc, the acetate of lead, and corrosive sublimate; the latter, however, from its poisonous qualities, can be employed only on special occasions. Nitrate of silver, though equally noxious to life, is so antiseptic, that a solution containing only $\frac{1}{500}$ of the salt is capable of preserving animal matters from corruption.

2. *Abstraction of water.*—Even in those cases where no separation of the albumen takes place in a coagulated form, or as a solid precipitate, by the operation of a substance foreign to the animal juices, putrefaction cannot go on, any more than other kinds of fermentation, in bodies wholly or in a great measure deprived of their water. For the albumen itself runs so much more slowly into putrefaction, the less water it is dissolved in; and in the desiccated state, it is as little susceptible of alteration as any other dry vegetable or animal matter. Hence, the proper drying of an animal substance becomes a universal preventive of putrescence. In this way fruits, herbs, cabbages, fish, flesh,

may be preserved from corruption. If the air be not cold and dry enough to cause the evaporation of the fluids before putrescence may come on, the organic substance must be dried by artificial means, as by being exposed in thin slices in properly constructed air-stoves. At temperatures under 140° F., the albumen dries up without coagulation, and may then be re-dissolved in cold water, with its valuable properties unaltered. By such artificial desiccation, if flesh is to be preserved for cooking or boiling, it must not be exposed, however, to so high a degree of heat, which would harden it permanently, like the baked mummies of Egypt. Mere desiccation, indeed, can hardly ever be employed upon flesh. Culinary salt is generally had recourse to, either alone or with the addition of saltpetre or sugar.

These alkaline salts abstract water in their solution, and, consequently, concentrate the aqueous solution of the albumen; whence, by converting the simple watery fluid into salt water, which is in general less favorable to the fermentation of animal matter than pure water, and by expelling the air, they counteract putridity. On this account, salted meat may be dried in the air much more speedily and safely than fresh meat. The drying is promoted by heating the meat merely to such a degree as to consolidate the albumen, and eliminate the superfluous water.

Alcohol operates similarly, in abstracting the water essential to the putrefaction of animal substances, taking it not only from the liquid albumen, but counteracting its decomposition, when mixed among the animal solids. Sugar acts in the same way, fixing in an unchangeable sirup the water which would otherwise be accessory to the fermentation of the organic bodies. The preserves of fruits and vegetable juices are made upon this principle. When animal substances are rubbed with charcoal powder or sand, perfectly dry, and are afterwards freely exposed to the air, they become deprived of their moisture, and will keep for any length of time.

3. *Defect of warmth.*—As a certain degree of heat is requisite for the vinous fermentation, so is it for the putrefactive. In a damp atmosphere, or in one saturated with moisture, if the temperature stand at from 70° to 80° F., the putrefaction goes on most rapidly; but it proceeds languidly at a few degrees above freezing, and is supended altogether at that point. The elephants preserved in the polar ices are proofs of the antiseptic influence of low temperature. In temperate climates, ice-houses serve the purpose of keeping meat fresh and sweet for any length of time.

4. *Abstraction of oxygen gas.*—As the putrefactive decomposition of a body first commences with the absorption of oxygen from the atmosphere, so it may be retarded by the exclusion of this gas. It is not, however, enough to remove the aerial oxygen from the surface of the body, but we must expel all the oxygen that may be diffused among the vessels and other solids, as this portion suffices in general to excite putrefaction, if other circumstances be favorable. The expulsion is most readily accomplished by a moderate degree of heat, which, by expanding the air, evolves it in a great measure, and at the same time favors the fixation of the oxygen in the extractive matter, so as to make it no longer available towards the putrefaction of the other substances. Milk, soup, solution of gelatine, &c., may be kept long in a fresh state, if they be subjected in an air-tight vessel every other day to a boiling heat. Oxygenation may be prevented in several ways: by burning sulphur or phosphorus in the air of the meat receiver; by filling this with compressed carbonic acid; or with oils, fats, sirups, &c., and then sealing it hermetically. Charcoal powder recently calcined is efficacious in preserving meat, as it not only excludes air from the bodies surrounded by it, but intercepts the oxygen by condensing it. When butcher-meat is enclosed in a vessel filled with sulphurous acid, it absorbs the gas, and remains for a considerable time proof against corruption. The same result is obtained if the vessel be filled with ammoniacal gas. At the end of 76 days such meat has still a fresh look, and may be safely dried in the atmosphere.

II. PECULIAR ANTISEPTIC PROCESSES.

Upon the preceding principles and experiments depend the several processes employed for protecting substances from putrescence and corruption. Here we must distinguish between those bodies which may be preserved by any media suitable to the purpose, as anatomical preparations or objects of natural history, and those bodies which, being intended for food, can be cured only by wholesome and agreeable means.

A common method for preserving animal substances unchanged in property and texture, is to immerse them in a spirituous liquor containing about 65 or 70 per cent. of real alcohol. Camphor may also be dissolved in it, and as much common salt as its water will take up. A double fold of ox-bladder should be bound over the mouth of the vessel, in order to impede the evaporation of the watery portion of the liquid, and its upper surface should be coated with a turpentine varnish. Undoubtedly a little creosote would be of use to counteract the decomposing influence of the alcohol upon the animal substances. With such an addition, a weaker spirit, containing no more than 30 per cent. of alcohol, would answer the purpose.

Instead of alcohol, a much cheaper vehicle is water saturated with sulphurous acid; and if a few drops of creosote be added, the mixture will become very efficacious. A solution of red sulphate of iron is powerfully antiseptic; but after some time it gives a deposite of the oxyde, which disguises the preparation in a great degree.

According to Tauffier, animal substances may be preserved more permanently by a solution of one part of chloride of tin in 20 parts of water, sharpened with a little muriatic acid, than even by alcohol.

For preserving animal bodies in an embalmed form, mummy-like, a solution of chloride of mercury and wood vinegar is most efficacious. As there is danger in manipulating with that mercurial salt, and as in the present state of our knowledge of creosote we have it in our power to make a suitably strong solution of this substance in vinegar or spirit of wine, I am led to suppose that it will become the basis of most antiseptic preparations for the future. From the statements of Pliny, it is plain that wood vinegar was the essential means employed by the ancient Egyptians in preparing their mummies, and that the odoriferous resins were of inferior consequence.

CURING OF PROVISIONS.

Flesh.—The ordinary means employed for preserving butcher meat are, drying, smoking, salting, and pickling or souring.

Drying of animal fibre.—The best mode of operating is as follows:—The flesh must be cut into slices from 2 to 6 ounces in weight, immersed in boiling water for 5 or 6 minutes, and then laid on open trellis-work in a drying-stove, at a temperature kept steadily about 122° F., with a constant stream of warm dry air. That the boiling water may not dissipate the soluble animal matters, very little of it should be used, just enough for the meat to be immersed by portions in succession, whereby it will speedily become a rich soup, fresh water being added only as evaporation takes place. It is advantageous to add a little salt, and some spices, especially coriander seeds, to the water. After the parboiling of the flesh has been completed, the soup should be evaporated to a gelatinous consistence, in order to fit it for forming a varnish to the meat after it is dried, which may be completely effected within two days in the oven. By this process two thirds of the weight is lost. The perfectly dry flesh must be plunged piece by piece in the fatty gelatinous matter liquefied by a gentle heat; then placed once more in the stove, to dry the layer of varnish. This operation may be repeated two or three times, in order to render the coat sufficiently uniform and thick. Butcher's meat dried in this way keeps for a year, affords, when cooked, a dish similar to that of fresh meat, and is therefore much preferable to salted provisions. The drying may be facilitated, so that larger lumps of flesh may be used, if they be imbued with some common salt immediately after the parboiling process, by stratifying them with salt, and leaving them in a proper pickling-tub for 12 hours before they are transferred to the stove. The first method, however, affords the more agreeable article.

Smoking.—This process consists in exposing meat previously salted, or merely rubbed over with salt, to wood smoke, in an apartment so distant from the fire as not to be unduly heated by it, and into which the smoke is admitted by flues at the bottom of the side walls. Here the meat combines with the empyreumatic acid of the smoke, and gets dried at the same time. The quality of the wood has an influence upon the smell and taste of the smoke-dried meat; smoke from beech wood and oak being preferable to that from fir and larch. Smoke from the twigs and berries of juniper, from rosemary, peppermint, &c., imparts somewhat of the aromatic flavor of these plants. A slow smoking with a slender fire is preferable to a rapid and powerful one, as it allows the empyreumatic principles time to penetrate into the interior substance, without drying the outside too much. To prevent soot from attaching itself to the provisions, they may be wrapped in cloth, or rubbed over with bran, which may be easily removed at the end of the operation.

The process of smoking depends upon the action of the wood acid, or the creosote volatilized with it, which operates upon the flesh. The same change may be produced in a much shorter time by immersing the meat for a few hours in pyroligneous acid, then hanging it up in a dry air, which, though moderately warm, makes it fit for keeping, without any taint of putrescence. After a few days exposure, it loses the empyreumatic smell, and then resembles thoroughly smoked provisions. The meat dried in this way is in general somewhat harder than by the application of smoke, and therefore softens less when cooked, a difference to be ascribed to the more sudden and concentrated operation of the wood vinegar, which effects in a few hours what would require smoking for several weeks. By the judicious employment of pyroligneous acid diluted to successive degrees, we might probably succeed in imitating perfectly the effect of smoke in curing provisions.

Salting.—The meat should be rubbed well with common salt, containing about one sixteenth of saltpetre, and one thirty-secondth of sugar, till every crevice has been impregnated with it; then sprinkled over with salt, laid down for 24 or 48 hours, and, lastly, subjected to pressure. It must next be sprinkled anew with salt, packed into proper vessels, and covered with the brine obtained in the act of pressing, rendered stronger by boiling down. For household purposes it is sufficient to rub the meat well with good salt, to put it into vessels, and load it with heavy weights, in order to squeeze out as much pickle as will cover its surface. If this cannot be had, a pickle must be poured on it, composed of 4 pounds of salt, 1 pound of sugar, and 2 oz. of saltpetre, dissolved in 2 gallons of water.

Pickling with vinegar.—Vinegar dissolves or coagulates the albumen of flesh, and thereby counteracts its putrescence. The meat should be washed, dried, and then laid in strong vinegar. Or it may be boiled in the vinegar, allowed to cool in it, and then set aside with it in a cold cellar, where it will keep sound for several months.

Fresh meat may be kept for some months in water deprived of its air. If we strew on the bottom of a vessel a mixture of iron filings and flowers of sulphur, and pour over them some water which has been boiled, so as to expel its air, meat immersed in it will keep a long time, if the water be covered with a layer of oil, from half an inch to an inch thick. Meat will also keep fresh for a considerable period when surrounded with oil, or fat of any kind, so purified as not to turn rancid of itself, especially if the meat be previously boiled. This process is called potting, and is applied successfully to fish, fowls, &c.

Prechtl says that living fish may be preserved 14 days without water, by stopping their mouths with crumbs of bread steeped in brandy, pouring a little brandy into them, and packing them in this torpid state in straw. When put into fresh water, they come alive again after a few hours! *Prechtl, Encyclop. Technologisches, art. Faülniss Abhaltung.*

Eggs.—These ought to be taken new laid. The essential point towards their preservation is the exclusion of the atmospheric oxygen, as their shells are porous, and permit the external air to pass inwards, and to excite putrefaction in the albumen. There is also some oxygen always in the air-cell of the eggs, which ought to be expelled or rendered inoperative, which may be done by plunging them for 5 minutes in water heated to 140° F. The eggs must be then taken out, wiped dry, besmeared with some oil (not apt to turn rancid) or other unctuous matter, packed into a vessel with their narrow ends uppermost, and covered with sawdust, fine sand, or powdered charcoal. Eggs coated with gum arabic, and packed in charcoal, will keep fresh for a year. Lime water, or rather milk of lime, is an excellent vehicle for keeping eggs in, as I have verified by long experience. Some persons coagulate the albumen partially, and also expel the air by boiling the eggs for 2 minutes, and find the method successful. When eggs are intended for hatching, they should be kept in a cool cellar; for example, in a chamber adjoining an ice-house. Eggs exposed, in the holes of perforated shelves, to a constant current of air, lose about ¾ of a grain of their weight daily, and become concentrated in their albuminous part, so as to be little liable to putrefy. For long sea voyages, the surest means of preserving eggs, is to dry up the albumen and yolk, by first triturating them into a homogeneous paste, then evaporating this in an air-stove or a water-bath heated to 125°, and putting up the dried mass in vessels which may be made air-tight. When used, it should be dissolved in three parts of cold or tepid water.

Grain of all kinds, as wheat, barley, rye, &c., and their flour, may be preserved for an indefinite length of time, if they be kiln-dried, put up in vessels or chambers free from damp, and excluded from the air. Well dried grain is not liable to the depredations of insects.

To preserve fruits in a fresh state, various plans are adopted. Pears, apples, plums, &c. should be gathered in a sound state, altogether exempt from bruises, and plucked, in dry weather, before they are fully ripe. One mode of preservation is, to expose them in an airy place to dry a little for eight or ten days, and then to lay them in dry sawdust or chopped straw, spread upon shelves in a cool apartment, so as not to touch each other. Another method consists in surrounding them with fine dry sand in a vessel which should be made air-tight, and kept in a cool place. Some persons coat the fruit, including their stalks, with melted wax; others lay the apples, &c., upon wicker-work shelves in a vaulted chamber, and smoke them daily during 4 or 5 days with vine branches or juniper wood. Apples thus treated, and afterwards stratified in dry sawdust, without touching each other, will keep fresh for a whole year.

The drying of garden fruits in the air, or by a kiln, is a well-known method of preservation. Apples and pears of large size should be cut into thin slices. From 5 to 6 measures of fresh apples, and from 6 to 7 of pears, afford in general one measure of dry fruit, (biffins). Dried plums, grapes, and currants are a common article of commerce.

Herbs, cabbages, &c., may be kept a long time in a cool cellar, provided they are covered with dry sand. Such vegetables are in general preserved for the purposes of food, by means of drying, salting, pickling with vinegar, or beating up with sugar. Cabbages should be scalded in hot water previously to drying; and all such plants, when dried, should be compactly pressed together, and kept in air-tight vessels. Tuberous and other roots are better kept in an airy place, where they may dry a little without being exposed to the winter's frost.

A partial drying is given to various vegetable juices by evaporating them to the consistence of a sirup, called a rob, in which so much of the water is dissipated as to prevent them from running into fermentation. The fruits must be crushed, squeezed in bags to expel the juices, which must then be inspissated either over the naked fire, or on a water or steam bath, in the air or in vacuo. Sometimes a small proportion of spices is added, which tends to prevent mouldiness. Such extracts may be conveniently mixed with sugar into what are called conserves.

Salting is employed for certain fruits, as small cucumbers or gherkins, capers, olives, &c. Even for peas such a method is had recourse to, for preserving them a certain time. They must be scalded in hot water, put up in bottles, and covered with saturated brine, having a film of oil on its surface, to exclude the agency of the atmospheric air. Before being used, they must be soaked for a short time in warm water, to extract the salt. The most important article of diet of this class, is the *sour kraut* of the northern nations of Europe (made from white cabbage), which is prepared simply by salting; a little vinegar being formed spontaneously by fermentation. The cabbage must be cut into small pieces, stratified in a cask along with salt, to which juniper berries and carui seeds are added, and packed as hard as possible by means of a wooden rammer. The cabbage is then covered with a lid, on which a heavy weight is laid. A fermentation commences, which causes the cabbage to become more compact, while a quantity of juice exudes and floats on the surface, and a sour smell is perceived towards the end of the fermentation. In this condition the cask is transported into a cool cellar, where it is allowed to stand for a year; and indeed, where, if well made and packed, it may be kept for several years.

The excellent process for preserving all kinds of butcher meat, fish, and poultry, first contrived by M. Appert in France, and afterwards successfully practised upon the great commercial scale by Messrs. Donkin and Gamble, for keeping beef, salmon, soups, &c. perfectly fresh and sweet for exportation from this country, as also turtle for importation thither from the West Indies, deserves a brief description.

Let the substance to be preserved be first parboiled, or rather somewhat more, the bones of the meat being previously removed. Put the meat into a tin cylinder, fill up the vessel with seasoned rich soup, and then solder on the lid, pierced with a small hole. When this has been done, let the tin vessel thus prepared be placed in brine and heated to the boiling point, to complete the remainder of the cooking of the meat. The hole of the lid is now to be closed perfectly by soldering, while the air is rarefied. The vessel is then allowed to cool, and from the diminution of the volume, in consequence of the reduction of temperature, both ends of the cylinder are pressed inwards, and become concave. The tin cases, thus hermetically sealed, are exposed in a test-chamber, for at least a month, to a temperature above what they are ever likely to encounter; from 90° to 110° of Fahrenheit. If the process has failed, putrefaction takes place, and gas is evolved, which, in process of time, will cause both ends of the case to bulge, so as to render them convex, instead of concave. But the contents of those cases which stand the test will infallibly keep perfectly sweet and good in any climate, and for any number of years. If there be any taint about the meat when put up, it inevitably ferments, and is detected in the proving process. Mr. Gamble's turtle is delicious.

This preservative process is founded upon the fact, that the small quantity of oxygen contained within the vessel gets into a state of combination, in consequence of the high temperature to which the animal substances are exposed, and upon the chemical principle, that free oxygen is necessary as a ferment to commence or give birth to the process of putrefaction.

I shall conclude this article with some observations upon the means of preserving water fresh on sea voyages. When long kept in wooden casks, it undergoes a kind of putrefaction, contracts a disagreeable sulphurous smell, and becomes undrinkable. The influence of the external air is by no means necessary to this change, for it happens in close vessels even more readily than when freely exposed to the atmospherical oxygen. The origin of this impurity lies in the animal and vegetable juices which the water originally contained in the source from which it was drawn, or from the cask, or insects, &c. These matters easily occasion, with a sufficient warmth, fermentation in the stagnant water, and thereby cause the evolution of offensive gases. It would appear that the gypsum of hard waters is decomposed, and gives up its sulphur, which aggravates the disagreeable odor; for selenitic waters are more apt to take this putrid taint, than those which contain merely carbonate of lime.

As the corrupted water has become unfit for use merely in consequence of the admixture of these foreign matters, for water in itself is not liable to corruption, so it may be purified again by their separation. This purification may be accomplished most easily by passing the water through charcoal powder, or through the powder of rightly calcined bone-black. The carbon takes away not only the finely diffused corrupt particles, but also the gaseous impurities. By adding to the water a very little sulphuric acid, about 30 drops to 4 pounds, Lowitz says that two thirds of the charcoal may be saved. Undoubtedly the sulphuric acid acts here, as in other similar cases, by the coagulation and separation of the albuminous matters, combining with them, and rendering them more apt to be seized by the charcoal. A more effectual agent for the purification of foul water is to be found in alum. A drachm of pounded alum should be dissolved with agitation in a gallon of the water, and then left to operate quietly for 24 hours. A sediment falls to the bottom, while the water becomes clear above, and may be poured off. The alum combines here with the substances dissolved in the water, as it does with the stuffs in the dyeing copper. In order to decompose any alum which may remain in solution, the equivalent quantity of crystals of carbonate of soda may be added to it.

The red sulphate of iron acts in the same way as alum. A few drops of its solution are sufficient to purge a pound of foul water. The foreign matters dissolved in the water, which occasion putrefaction, become insoluble, in consequence of oxydizement, like vegetable extractive, and are precipitated. On this account, also, foul water may be purified, by driving atmospheric air through it with bellows, or by agitating it in contact with fresh air, so that all its particles are exposed to oxygen. Thus we can explain the influence of streams and winds, in counteracting the corruption of water exposed to them. Chlorine acts still more energetically than the air in purifying water. A little aqueous chlorine added to foul water, or the transmission of a little gaseous chlorine through it, cleanses it immediately.

Water-casks ought to be charred inside, whereby no fermentable stuff will be extracted from the wood. British ships, however, are now commonly provided with iron tanks for holding their water in long voyages.

PYRITES, is the native bisulphuret of iron. Copper pyrites, called vulgarly mundick, is a bisulphuret of copper.

PYRO-ACETIC SPIRIT. (*Esprit pyro-acétique*, *Acétone*, Fr.; *Brennzlicher Essiggeist*, *Mesit*, Germ.) This liquid was discovered and described by Chenevix long before *pyroligneous spirit* was known. It may be obtained by subjecting to dry distillation the acetates of copper, lead, alkalis, and earths; and as it is formed especially during the second half of the process, the liquor which comes over then should be set apart, separated by decantation from the empyreumatic oil, and distilled a second time by the heat of a water-bath. The fine light fluid which now comes over first, is to be rectified along with carbonate of potassa, or chloride of calcium. As pyro-acetic spirit usually retains, even after repeated distillations, a disagreeable empyreumatic smell, like garlic, a little good bone-black should be employed in its final rectification. According to Reichenbach, pyro-acetic spirit may be extracted in considerable quantity from beech tar. (See the next article.) The spirit thus prepared is a colorless limpid liquid, of an acrid and burning taste at first, but afterwards cooling; of a penetrating aromatic smell, different from that of alcohol; of the spec. gravity 0·7921 at 60° F., boiling at 132° F., and remaining fluid at 5°. It consists ultimately of—carbon, 62·148; hydrogen, 10·453; oxygen, 27·329; or, of 1 proportion of carbonic acid + 2 prop. of olefiant gas + 1 prop. of water; or, 1 prop. of acetic acid — 1 prop. of carbonic acid. According to another view, it is composed of, 51·52 parts of concentrated acetic acid, and 48·488 of oil of wine, being double of the quantity in acetic ether. It is very combustible, and burns with a brilliant flame, without smoke. When treated by chlorine, it loses an atom of its hydrogen, and absorbs 2 atoms of chlorine. It is soluble in water, alcohol, ether, and is not convertible into ether by strong sulphuric acid. It is used for dissolving the resins commonly called gums, with which the bodies of hats are stiffened.

PYROLIGNEOUS ACID. In addition to what has been said under ACETIC ACID, I shall here describe the process as conducted upon a great scale at an establishment near Manchester. The retorts are of cast iron, 6 feet long, and 3 feet 8 inches in diameter. Two of these cylinders are heated by one fire, the flame of which plays round their sides and upper surface; but the bottom is shielded by fire-tiles from the direct action of the fire. 2 cwts. of coals are sufficient to complete the distillation of one charge of wood; 36 imperial gallons of crude vinegar, of specific gravity 1·025, being obtained from each retort. The process occupies 24 hours. The retort-mouth is then removed, and the ignited charcoal is raked out for extinction into an iron chest, having a groove round its edges, into which a lid is fitted.

When this pyroligneous acid is saturated with quicklime, and distilled, it yields one per cent. of pyroxilic spirit (sometimes called naptha); which is rectified by two or three successive distillations with quicklime.

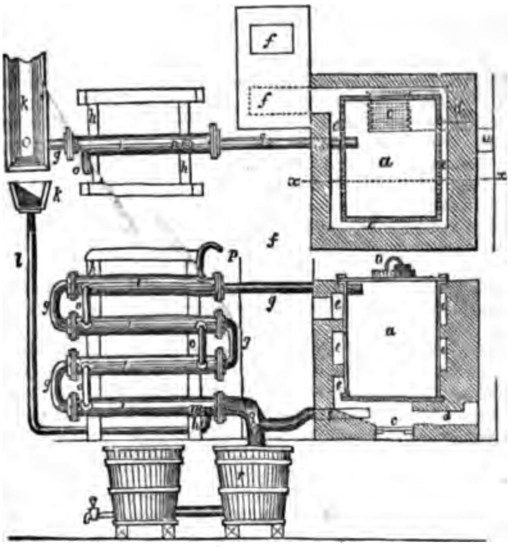
The tarry deposite of the crude pyroligneous acid, being subjected to distillation by itself, affords a crude pyro-acetic ether, which may also be purified by re-distillation with quicklime, and subsequent agitation with water.

The pyrolignite of lime is made by boiling the pyroligneous acid in a large copper, which has a sloping spout at its lip, by which the tarry scum freely flows over, as it froths up with the heat. The fluid compound thus purified is syphoned off into another copper, and mixed with a quantity of alum equivalent to its strength, in order to form the red liquor, or acetate of alumina, of the calico-printer. The acetate of lime, and sulphate of alumina and potash, mutually decompose each other; with the formation of sulphate of lime, which falls immediately to the bottom.

M. Kestner, of Thann, in Alsace, obtains, in his manufactory of pyroligneous acid, 5 hectolitres (112 gallons imperial, nearly) from a cord containing 93 cubic feet of wood. The acid is very brown, much loaded with tar, and marks 5° Baumé; 220 kilogrammes of charcoal are left in the cylinders; 500 litres of that brown acid produce, after several distillations, 375 of the pyroligneous acid of commerce, containing 7 per cent. of acid, with a residuum of 40 kilogrammes of pitch. For the purpose of making a crude acetate of lead (pyrolignite) he dries pyrolignite of lime upon iron plates, mixes it with the equivalent decomposing quantity of sulphuric acid, previously diluted with its own weight of water, and cooled; and transfers the mixture as quickly as possible into a cast-iron cylindric still, built horizontally in a furnace; the under half of the mouth of the cylinder being always cast with a semicircle of iron. The acetic acid is received into large salt-glazed stone bottles. From 100 parts of acetate of lime, he obtains 133 of acetic acid, at 38° Baumé. It contains always a little sulphurous acid from the reaction of the tar and the sulphuric acid.

The apparatus represented in *figs.* 929 and 930 is a convenient modification of that exhibited under acetic acid, for producing pyroligneous acid. *Fig.* 929 shows the furnace in a horizontal section drawn through the middle of the flue which leads to the chimney. *Fig.* 930 is a vertical section taken in the dotted line x, x, of *fig.* 929. The chest *a* is constructed with cast-iron plates bolted together, and has a capacity of 100 cubic feet. The wood is introduced into it through the opening *b*, in the cover, for which purpose it is cleft into billets of moderate length. The chest is heated from the subjacent grate *c*, upon which the fuel is laid, through the fire-door *d*. The flame ascends spirally through the flues *e*, *e*, round the chest, which terminate in the chimney *f*. An iron pipe *g* conveys the vapors and gaseous products from the iron chest to the condenser. This consists of a series of pipes laid zigzag over each other, which rest upon a framework of wood. The condensing tubes are enclosed in larger pipes *i*, *i*; a stream of cold water being caused to circulate in the interstitial spaces between them. The water passes down from a trough *k*, through a conducting tube *l*, enters the lowest cylindrical case at *m*, flows thence along the series of jackets *i*, *i*, *i*, being transmitted from the one row to the next above it, by the junction tubes *o*, *o*, *o*, till at *p* it runs off in a boiling-hot state. The vapors proceeding downwards in an opposite direction to the cooling stream of water, get condensed into the liquid state, and pass off at *q*, through a discharge pipe, into the first close receiver *r*, while the combustible gases flow off through the tube *s*, which is provided with a stopcock to regulate the magnitude of their flame under the chest. As soon as the distillation is fully set agoing, the stopcock upon the gas-pipe is opened; and after it is finished, it must be shut. The fire should be

929



supplied with fuel at first, but after some time the gas generated keeps up the distilling heat. The charcoal is allowed to cool during 5 or 6 hours, and is then taken out through an aperture in the back of the chest, which corresponds to the opening *u*, *fig.* 929, in the brickwork of the furnace. About 60 per cent. of charcoal may be obtained from 100 feet of fir-wood, with a consumption of as much brush-wood for fuel.

Stoltze has ascertained, by numerous experiments, that one pound of wood yields from 6 to 7½ ounces of liquid products; but in acetic acid it affords a quantity varying from 2 to 5, according to the nature of the wood. Hard timber, which has grown slowly upon a dry soil, gives the strongest vinegar. White birch and red beech afford per pound 7½ ounces of wood vinegar, 1½ ounce of combustible oil, and 4 ounces of charcoal. One ounce of that vinegar saturates 110 grains of carbonate of potassa. Red pine yields per pound 6½ ounces of vinegar, 2½ ounces of oil, 3¾ ounces of charcoal; but one ounce of the vinegar saturates only 44 grains of carbonate of potassa, and has therefore only two fifths of the strength of the vinegar from the birch. An ounce of the vinegar from the white beech, holly oak (*Ilex*), common ash, and horse chestnut, saturates from 90 to 100 grains of the carbonate. In the same circumstances, an ounce of the vinegar of the alder and white pine saturates from 58 to 60 grains.

PYROLIGNEOUS or **PYROXILIC SPIRIT**, improperly called naptha. This is employed, as well as pyro-acetic ether, to dissolve the sandarach, mastic, and other resinous substances, which, under the name of gums, are used for stiffening the bodies of hats. I have already described, in the article PYROLIGNEOUS ACID, how this spirit is obtained. Berzelius has found that the crude spirit may be best purified by agitating it with a fat oil, in order to abstract the empyreumatic oil; then to decant the spirit, distil it, first with fresh calcined charcoal, and next with chloride of calcium. The pyroligneous spirit, thus purified, is colorless, and limpid like alcohol; has an ethereous smell, somewhat resembling that of ants. Its taste is hot, and analogous to that of oil of peppermint. Its specific gravity, by my experiments, is 0·824. It readily takes fire, and burns with a blue flame, without smoke. It combines with water in any proportion; a property which distinguishes it from pyro-acetic ether and spirit.

It is not easy to say what is the real chemical nature of pyroxilic spirit. There is no ultimate analysis of it that can be depended upon. The properties of the spirit examined by MM. Marcet and Macaire, differ from those of our spirit, in refusing to combine with water, like alcohol. The article on sale in this country readily unites with water, and in all proportions with alcohol.

PYROMETER is the name of an instrument for measuring high degrees of heat above the range of the mercurial thermometer. Wedgewood's is the one commonly referred to by writers upon porcelain and metallurgy; but a better one might be easily contrived.

PYROPHORUS is the generic name of any chemical preparation, generally a powder, which inflames spontaneously when exposed to the air.

PYROTECHNY. See FIRE-WORKS.

PYROXILINE is a name which I have ventured to give to a substance detected in pyroxylic spirit, by Mr. Scanlan, while residing in Dublin, and therefore called by him *Eblanin*. I am indebted to that ingenious chemist for the following facts.

If potash water be added to raw wood-spirit (*pyroligneous*), as long as it throws down anything, a precipitate is produced, which is *pyroxiline*, mixed with tarry matter. This precipitate is to be collected on a filter cloth, and submitted to strong pressure between folds of blotting-paper; it is next to be washed with cold alcohol, spec. grav. 0·840, in order to free it from any adhering tarry matter; when the pyroxiline is left nearly pure. If it be dissolved in boiling alcohol, or hot oil of turpentine, it crystallizes regularly on cooling, in right square prisms, of a fine yellow color, that look opaque to the naked eye, but when examined under the microscope, have the transparency and color of ferroprussiate of potash. Its turpentine solution affords crystals of a splendid orange-red color, having the appearance of minute plates, whose form is not discernible by the naked eye, but when examined by the microscope, they are seen to be thin right rectangular prisms. The orange-red color is only the effect of aggregation; for when ground to powder, these crystals become yellow; and under the microscope, the difference in color between the two is very slight. Its melting point is 318° F. It sublimes at 300° in free air; heated in a close tube in a bath of mercury, it emits vapor at 400°; it then begins to decompose, and is totally decomposed at 500°. Sulphuric acid decomposes it, producing a beautiful blue color, which passes into crimson, as the acid attracts water from the atmosphere, and it totally disappears on plentiful dilution with water, leaving carbon of a dirty-brown color. Its alcoholic or turpentine solution imparts a permanent yellow dye to vegetable or animal matter.

Pyroxiline consists, according to the analysis of Drs. Apjohn and Gregory, of—carbon, 75·275; hydrogen, 5·609; oxygen, 19·116, in 100 parts.

Q.

QUARTATION is the alloying of one part of gold that is to be refined, along with three parts of silver, so that the gold shall constitute one *quarter* of the whole, and thereby have its particles too far separated to be able to protect the other metals originally associated with it, such as silver, copper, lead, tin, palladium, &c., from the action of the nitric or sulphuric acid employed in the subsequent parting process. See REFINING.

QUARTZ has been described in the article LAPIDARY.

QUASSIA is the wood of the root of the *Quassia excelsa*, a tree which grows in Surinam, the East Indies, &c. It affords to water an intensely bitter decoction, which is occasionally used in medicine, and was formerly substituted by some brewers for hops, but is now prohibited under severe penalties. It affords a safe and efficacious fly-water, or poison for flies.

QUEEN'S WARE. See POTTERY.

QUEEN'S YELLOW is an ancient name of Turbith Mineral, or yellow subsulphate of mercury.

QUERCITRON is the bark of the *Quercus nigra*, or yellow oak, a tree which grows in North America. The coloring principle of this yellow dye-stuff has been called *Quercitrin*, by its discoverer Chevreul. It forms small pale yellow spangles, like those of *Aurum musivum*, has a faint acid reaction, is pretty soluble in alcohol, hardly in ether, and little in water. Solution of alum developes from it, by degrees, a beautiful yellow dye. See CALICO-PRINTING and YELLOW DYE.

QUICKLIME; see LIME.

QUICKSILVER; see MERCURY.

QUILL; see FEATHERS.

QUININA. This medicine is now prepared in such quantities as to constitute a chemical manufacture. Quinina and cinchonina are two vegetable alkalis, which exist in Peruvian bark or cinchona; the pale or gray bark contains most cinchonina, and the yellow bark most quinina. The methods of extracting these bases are very various. In general, water does not take them out completely, because it transforms the neutral salts in the barks into more soluble acidulous salts, and into less soluble sub-salts. To exhaust the bark completely, one or other of the following solvents is employed:

1. *Alcohol.*—An extract by this menstruum, is to be treated with very dilute warm muriatic acid, in order to dissolve everything thus soluble; the acid liquor is to be saturated with magnesia, by boiling it with an excess of this earth; the precipitate is to be dried, filtered, and then exhausted by boiling-hot alcohol.

2. *Dilute acids.*—Boil the bark, coarsely pounded, with eight times its weight of water, containing 5 per cent. of the weight of the bark of sulphuric acid. This treatment is to be repeated with a fresh quantity of dilute acid. The whole liquors must be filtered, the residuum strained, and the solution mixed with quicklime, equal to one fourth of the bark employed. This mixture, after having been well stirred, is to be strained, whenever it acquires an alkaline reaction, that is, tinges reddened litmus paper blue, or turmeric brown. The calcareous mass is to be now washed with a little water, and dried, and then boiled thrice with spirit of wine of spec. grav. 0·836. This solution being filtered, is to be mixed with a little water, and distilled. The bases, cinchonina and quinina, remain under the form of a brown viscid mass, and must be purified by subsequent crystallization, after being converted into sulphates.

3. *An alkali, and then an acid.*—The object of this process is, to retain the vegetable alkalis in the bark, while with the alkaline water we dissolve out the acids, the coloring matters, the extractive, the gum, &c. Boil for an hour one pound of the bark with six pounds of water, adding by degrees a little solution of potash, so that the liquor may have still an alkaline taste when the boiling is over. Allow it to cool, filter, wash the residuum with a little water, and squeeze it. Diffuse it next in tepid water, to which add by degrees a little muriatic acid, till after a prolonged digestion the mixture shall perceptibly redden litmus paper. Filter the liquor, and boil it with magnesia. The precipitate being washed and dried, is to be treated with hot alcohol, which dissolves the quinina and cinchonina.

Obtained by any of the above methods, the quinina and cinchonina are more or less colored, and may be blanched by dissolving them in dilute muriatic acid, and treating the solution with animal charcoal.

There are several methods of separating these two vegetable alkalis.

1. When their solution in spirit of wine is evaporated by heat to a certain point, the greater part of the cinchonina crystallizes on cooling, while the quinina remains dissolved.

2. Digestion in ether dissolves the quinina, and leaves the cinchonina.

3. We may supersaturate slightly the two bases with sulphuric acid. Now as the supersulphate of quinina is sparingly soluble, the liquor need only to be evaporated to a proper point to crystallize out that salt, while the supersulphate of cinchonina continues in solution with very little of the other salt. Even this may be separated by precipitating the bases, and treating them, as above prescribed, with alcohol or ether.

One pound of bark rarely yields more than 2 drachms of the bases. One pound of red bark afforded, to Pelletier and Caventou, 74 grains of cinchonina, and 107 grains of quinina.

Quinina is composed of 75·76 carbon, 7·52 hydrogen, 8·11 azote, and 8·61 oxygen.

The salts of quinina are distinguished by their strong taste of Peruvian bark, and if crystallized, by their pearly lustre. Most of them are soluble in water, and some also in ether and alcohol. The soluble salts are precipitated by the oxalic, gallic, and tartaric acids, and by the salts of these acids. Infusion of nutgalls also precipitates them.

The sulphate of quinina is the only object of manufacturing operations. Upon the brownish viscid mass obtained in any of the above processes for obtaining quinina, pour very dilute sulphuric acid, in sufficient quantity to produce saturation. The solution must be then treated with animal charcoal, filtered, evaporated, allowed to cool, when it deposites crystals. 1000 parts of bark afford, upon an average, 12 parts of sulphate. The sulphate of cinchonina, which is formed at the same time, remains dissolved in the mother-waters.

The neutral sulphate of quinina occurs in small transparent right prismatic needles. By spontaneous evaporation of their solution, larger crystals may be procured. They contain 24$\frac{2}{3}$ per cent. of water; and, therefore, melt when exposed to heat. They dissolve in 11 parts of water at ordinary temperatures; are much more soluble in hot spirit of wine, somewhat dilute, than in cold; and are nearly insoluble in anhydrous alcohol. If they be well dried, they possess the property of becoming luminous when heated a little above the boiling point of water, especially when they are rubbed. The sulphate is, in this case, charged with vitreous electricity.

There is a sub-sulphate, but it is applied to no use. The effloresced sulphate, called by some bisulphate, is preferred for medical practice. The extensive sale and high price of sulphate of quinina, have given rise to many modes of adulteration. It has been mixed with boracic acid, margaric acid, sugar, sugar of manna, gypsum, &c. By incinerating a little of the salt upon a slip of platina, the boracic acid and gypsum remain, while the quinine is dissipated; sugar and margaric acid exhale their peculiar smoke and smell; or they may be dissolved out by a few drops of water. Cinchonina may be detected by adding ammonia to the solution, and treating the precipitate with ether, which leaves that vegeto-alkali.

QUINTESSENCE. The alchemists understood by this term, now no longer in scientific use, the solution in alcohol of the principles which this menstruum can extract from aromatic plants or flowers, by digestion, during some days, in the sun, a stove, or upon a sand-bath slightly warmed. A quintessence, therefore, corresponds to the alcoholic tincture or essence (not essential oil) of the present day. See PERFUMERY.

R.

RAISINS, are grapes allowed to ripen and dry upon the vine. The best come from the south of Europe, as from Roquevaire in Provence, Calabria, Spain, and Portugal. Fine raisins are also imported from Smyrna, Damascus, and Egypt. Sweet fleshy grapes are selected for maturing into raisins, and such as grow upon the sunny slopes of hills sheltered from the north winds. The bunches are pruned, and the vine is stripped of its leaves, when the fruit has become ripe; the sun then beaming full upon the grapes, completes their saccharification, and expels the superfluous water. The raisins are plucked, cleansed, and dipped for a few seconds in a boiling ley of wood ashes and quicklime, at 12 or 13 degrees of Baumé's areometer. The wrinkled fruit is lastly drained, dried, and exposed in the sun upon hurdles of basket-work during 14 or 15 days.

The finest raisins are those of the sun, so called; being the plumpest bunches, which are left to ripen fully upon the vine, after their stalks have been half cut through.

The amount of raisins imported for home consumption was, in the year 1836, 156,495 cwts.; in 1837, 152,635 cwts.

RAPE-SEED, imported for home consumption in 1836, 561,457 bushels; in 1837, 937,526 bushels. See OILS, UNCTUOUS.

RASP, MECHANICAL, is the name given by the French to an important machine much used for mashing beet-roots. See SUGAR.

RATAFIA, is the generic name, in France, of *liqueurs* compounded with alcohol, sugar, and the odoriferous or flavoring principles of vegetables. Bruised cherries with their stones are infused in spirit of wine to make the ratafia of Grenoble *de Teyssère*. The liquor being boiled and filtered, is flavored, when cold, with spirit of *noyau*, made by distilling water off the bruised bitter kernels of apricots, and mixing it with alcohol. Sirup of bay laurel and galango are also added.

REALGAR, *Red Orpiment*. (*Arsenic rouge sulphuré*, Fr.; *Rothes schwefelarsenik*, Germ.) This ore occurs in primitive mountains, associated sometimes with native arsenic, under the form of veins, efflorescences, very rarely crystalline; as also in volcanic districts; for example, at Solfaterra near Naples; or sublimed in the shape of stalactites, in the rents and craters of Etna, Vesuvius, and other volcanoes. Its spec. grav varies from 3·3 to 3·6. It has a fine scarlet color in mass, but orange-red in powder, whereby it is distinguishable from cinnabar. It is soft, sectile, readily scratched by the nail; its fracture is vitreous and conchoidal. It volatilizes easily before the blowpipe, emitting the garlic smell of arsenic, along with that of burning sulphur. It consists of, arsenic 70, sulphur 30, in 100 parts. It is employed sometimes as a pigment. Factitious orpiment is made by distilling, in an earthen retort, a mixture of sulphur and arsenic, of orpiment and sulphur, or of arsenious acid, sulphur, and charcoal. It has not the rich color of the native pigment, and is much more poisonous; since, like factitious orpiment, it always contains more or less arsenious acid.

RECTIFICATION, is a second distillation of alcoholic liquors, to free them from whatever impurities may have passed over in the first.

RED LIQUOR, is a crude acetate of alumina, employed in calico-printing, and prepared from pyroligneous acid; which see.

REED, is the well-known implement of the weaver, made of parallel slips of metal or reeds, called dents. A thorough knowledge of the adaption of yarn of a proper degree of fineness to any given measure of reed, constitutes one of the principal objects of the manufacturer of cloths; as upon this depends entirely the appearance, and in a great degree the durability, of the cloth when finished. The art of performing this properly, is known by the names of *examining*, *setting*, or *sleying*, which are used indiscriminately, and mean exactly the same thing. The reed consists of two parallel pieces of wood, set a few inches apart, and they are of any given length, as a yard, a yard and a quarter, &c. The division of the yard being into halves, quarters, eighths, and sixteenths; the breadth of a web is generally expressed by a vulgar fraction, as $\frac{1}{4}$, $\frac{4}{4}$, $\frac{5}{4}$, $\frac{6}{4}$; and the subdivisions by the eighths or sixteenths, or *nails*, as they are usually called, as $\frac{7}{8}$, $\frac{9}{8}$, $\frac{11}{8}$ &c., or $\frac{13}{16}$, $\frac{15}{16}$, $\frac{19}{16}$, &c. In Scotland, the splits of cane which pass between the longitudinal pieces or ribs of the reed, are expressed by hundreds, porters, and splits. The porter is 20 splits, or $\frac{1}{5}$th of a hundred.

In Lancashire and Cheshire a different mode is adopted, both as to the measure and divisions of the reed. The Manchester and Bolton reeds are counted by the number of splits, or, as they are there called, dents, contained in 24¼ inches of the reed. These dents, instead of being arranged in hundreds, porters, and splits, as in Scotland, are calculated by what is there termed *hares* or *bears*, each containing 20 dents, or the same number as the porter in the Scotch reeds. The Cheshire or Stockport reeds, again, receive their designation from the number of ends or threads contained in one inch, two ends being allowed for every *dent*, that being the almost universal number in every species and description of plain cloth, according to the modern practice of weaving, and also for a great proportion of fanciful articles.

The number of threads in the warp of a web is generally ascertained with considerable precision by means of a small magnifying glass, fitted into a socket of brass, under which is drilled a small round hole in the bottom plate of the standard. The number of threads visible in this perforation, ascertains the number of threads in the standard measure of the reed. Those used in Scotland have sometimes four perforations, over any one of which the glass may be shifted. The first perforation is ¼ of an inch in diameter, and is therefore well adapted to the Stockport mode of counting; that is to say, for ascertaining the number of ends or threads per inch; the second is adapted for the Holland reed, being $\frac{1}{200}$th part of 40 inches; the third is $\frac{1}{700}$th of 37 inches, and is adapted for the now almost universal construction of Scotch reeds; and the fourth, being $\frac{1}{200}$th of 34 inches, is intended for the French cambrics. Every thread appearing in these respective measures, of course represents 200 threads, or 100 splits, in the standard breadth; and thus the quality of the fabric may be ascertained with considerable precision, even after the cloth has undergone repeated wettings, either at the bleaching-ground or dye-work. By counting the other way, the proportion which the woof bears to the warp is also known, and this forms the chief use of the glass to the manufacturer and operative weaver, both of whom are previously acquainted with the exact measure of the reed.

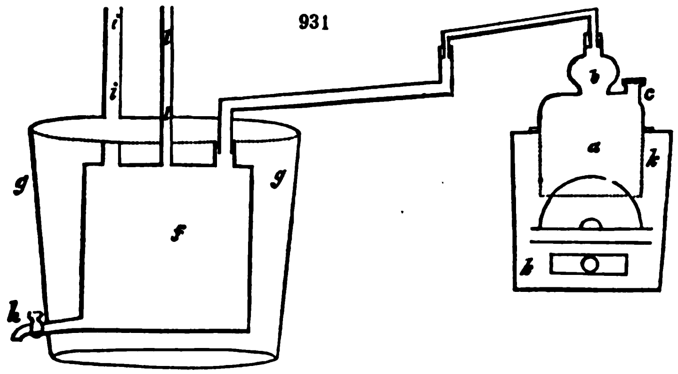
Comparative TABLE of 37-inch reeds, being the standard used throughout Europe, for linens, with the Lancashire and Cheshire reeds, and the foreign reeds used for holland and cambric.

Scotch.	Lancashire.	Cheshire.	Dutch holland.	French cambric.
600	20	34	550	653
700	24	38	650	761
800	26	44	740	870
900	30	50	832	979
1000	34	54	925	1089
1100	36	60	1014	1197
1200	40	64	1110	1300
1300	42	70	1202	1414
1400	46	76	1295	1464
1500	50	80	1387	1602
1600	52	86	1480	1752
1700	56	92	1571	1820
1800	58	96	1665	1958
1900	62	104	1757	2067
2000	66	110	1850	2176

In the above table, the 37-inch is placed first. It is called Scotch, not because it either originated or is exclusively used in that country. It is the general linen reed of all Europe; but in Scotland it has also been adopted as the regulator of her cotton manufactures.

REFINING OF GOLD AND SILVER; called also *Parting*. (*Affinage d'argent, Départ*, Fr.; *Scheidung in die quart*, Germ.) For several uses in the arts, these precious metals are required in an absolutely pure state, in which alone they possess their malleability and peculiar properties in the most eminent degree. Thus, for example, neither gold nor silver leaf can be made of the requisite fineness, if the metals contain the smallest portion of copper alloy. Till within these ten or twelve years, the parting of silver from gold was effected everywhere by nitric acid; it is still done so in all the establishments of this country, except the Royal Mint; and in the small refining houses abroad. The following apparatus may be advantageously employed in this operation. It will serve the double purpose of manufacturing nitric acid of the utmost purity, and of separating silver from gold by its means.

931



1. *On procuring nitric acid for parting.*—*a* is a platinum retort or alembic; *b* is its capital, terminating above in a tubulure, to which a kneed tube of platinum, about 2 feet long, is adapted; *c* is the tubulure of the retort, for supplying acid during the process, and for inspecting its progress. It is furnished with a lid ground air-tight, which may be secured in its place by a weight. *e* is a stoneware pipe, about two inches diameter, and several feet long, according to the locality in which the operation is to be carried on. It is made in lengths fitted to one another, and secured at the joints with loam-lute. The one bend of this earthenware hard salt-glazed pipe is adapted to receive the platinum tube, and the other bend is inserted into a tubulure in the top of the stoneware drum *f*. The opening *l*, *l*, in the middle of the top of *f*, is

for inspecting the progress of the condensation of acid; and the third tubulure terminates in a prolonged pipe *i*, *i*, consisting of several pieces, each of which enters from above conically into the one below. The joinings of the upper pieces need not be tightly luted, as it is desirable that some atmospherical oxygen should enter, to convert the relatively light nitrous gas into nitrous or nitric acid vapor, which when supplied with moisture will condense and fall down in a liquid state. To supply this moisture in the most diffusive form, the upright stoneware pipes *i*, *i*, *l*, *l*, (at least 3 inches diameter, and 12 feet high), should be obstructed partially with flint nodules, or with silicious pebbles; and water should be allowed to trickle upon the top pebble from a cistern placed above. Care must be taken to let the water drop so slowly as merely to preserve the pebbles in a state of humidity. *h* is a stopcock, of glass or stoneware, for drawing off the acid from the cistern *f*. *k* is a section of a small air-furnace, covered in at top with an iron ring, on which the flat iron ring of the platinum frame rests.

g, *g*, is a tub in which the stoneware cistern stands, surrounded with water, kept constantly as cold as possible by passing a stream through it; the spring water entering by a pipe that dips near to the bottom, and the hot water escaping at the upper edge.

With the above apparatus, the manufacture of pure nitric acid is comparatively easy and economical. Into the alembic *a*, 100 pounds (or thereby) of pure nitre, coarsely bruised if the crystals be large, are to be put; the capital is then to be adapted, and the platinum tube (the only moveable one) luted into its place. Twenty pounds of strong sulphuric acid are now to be introduced by the tubulure *c*, and then its lid must be put on. No heat must yet be applied to the alembic. In about an hour, another ten pounds of acid may be poured in, and so every hour, till 60 pounds of acid have been added. A few hours after the affusion of the last portion of acid, a slight fire may be kindled in the furnace *k*.

By judicious regulation of the heat, the whole acid may be drawn off in 24 hours; its final expulsion being aided by the dexterous introduction of a quart or two of boiling water, in small successive portions, by the tubulure *c*, whose lid must be instantly shut after every inspersion. The most convenient strength of acid for the parting process, is when its specific gravity is about 1·320, or when a vessel that contains 16 ounces of pure water, will contain 21⅛ of the aquafortis. To this strength it should be brought very exactly by the aid of a hydrometer.

Its purity is easily ascertained by letting fall into it a few drops of solution of silver; and if no perceptible milkiness ensues, it may be accounted good. Should a white cloud appear, a few particles of silver may be introduced, to separate whatever muriatic acid may be present, in the form of chloride of silver. Though a minute quantity of sulphuric acid should exist in the nitric, it will be of no consequence in the operation of parting.

2. *On parting by the nitric acid, called by the Mexicans, "Il apartado."*—The principle on which this process is founded, is the fact of silver being soluble in nitric acid, while gold is insoluble in that menstruum. If the proportion of gold to that of silver be greater than one to two, then the particles of the former metal so protect or envelop those of the latter, that the nitric acid, even at a boiling heat, remains quite inactive on the alloy. It is indispensable, therefore, that the weight of the silver be at least double that of the gold. 100 pounds of silver take 38 pounds of nitric acid, of specific gravity 1·320, for oxydizement, and 111 for solution of the oxyde; being together 149; but the refiner often consumes, in acid of the above strength, more than double the weight of silver, which shows great waste, owing to the imperfect means of condensation employed for recovering the vapors of the boiling and very volatile acid.

By the apparatus above delineated, the 38 pounds of acid expended in oxydizing the silver, become nitrous gas in the first place, and are afterwards reconverted in a great measure into nitric acid by absorption of atmospherical oxygen; so that not one fifth need be lost, under good management. As the acid must be boiled on the granulated *garble*, or alloy, to effect the solution of the silver, by proper arrangements the vapors may be entirely condensed, and nearly the whole acid be recovered, except the 111 parts indispensable to constitute nitrate of silver. Hence, with economical management, 120 pounds of such acid may be assigned as adequate to dissolve 100 of silver associated with 50 of gold.

It must here be particularly observed, that 100 pounds of copper require 130 pounds of the above acid for oxydizement; and 390 for solution of the oxyde; being 520 pounds in whole, of which less than ¼ part could be recovered by the above apparatus. It is therefore manifest that it is desirable to employ silver pretty well freed from copper by a previous process; and always, if practicable, a silver containing some gold.

These data being assumed as the bases of the parting operation, 60 pounds of gold and silver alloy or *garble* finely granulated, containing not less than 40 pounds of silver, are to be introduced into the ten-gallon alembic of platinum, *fig.* 931, and 80 pounds of nitric acid, of 1·320, is to be poured over the alloy; a quantity which will measure 6 gallons imperial. As for the bulk of the alloy, it is considerably less than half a gallon. Abundance of space therefore remains in the alembic for effervescence and ebullition, provided the fire be rightly tempered.

By the extent of stoneware conducting pipe *e*, which should not be less than 40 feet, by the dimensions and coldness of the cistern *f*, and by the regenerating influence of the vertical aerial pipe filled with moist pebbles *i*, *i*, it is clear, that out of the 80 pounds of nitric acid, specific gravity 1·320, introduced at first, from 20 to 30 will be recovered.

Whenever the effervescence and disengagement of nitrous red fumes no longer appear on opening the orifice *c*, the fire must be removed, and the vessel may be cooled by the application of moist cloths. The alembic may be then disengaged from the platinum tube, and lifted out of its seat. Its liquid contents must be cautiously decanted off, through the orifice *c*, into a tub nearly filled with soft water. On the heavy pulverulent gold which remains in the vessel, some more acid should be boiled, to carry off any residuary silver. This metallic powder, after being well washed with water, is to be dried, fused along with a little nitre or borax, and cast into ingots.

Plates of copper being immersed in the nitric solution contained in wooden or stoneware cisterns, will throw metallic silver down, while a solution of nitrate of copper, called blue water, will float above. The pasty silver precipitate is to be freed from the nitrate of copper, first, by washing with soft water, and next, by strong hydraulic pressure in cast iron cylinders. The condensed mass, when now melted in a crucible along with a little nitre and borax, is fine silver.

The above apparatus has the further advantage of enabling the operator to recover a great portion of his nitric acid, by evaporating the blue water to a state approaching to dryness, with the orifices at *c*, and at the top of the capital, open. In the progress of this evaporation, nothing but aqueous vapor escapes. Whenever the whole liquid is dissipated, the pipe *d* is to be re-adjusted, and the lid applied closely to *c*. The heat being now continued, and gradually increased, the *whole* nitric acid will be expelled from the copper oxyde, which will remain in a black mass at the bottom of the alembic. The contrivance for letting water trickle upon the pebbles, must be carefully kept in play, otherwise much of the evolved acid would be dissipated in nitrous fumes. With due attention to the regenerative plan, a great part of the acid may be recovered, at no expense but that of a little fuel.

The black oxyde of copper thus obtained, is an economical form of employing that metal for the production of the sulphate; 100 pounds of it, with 122½ of sulphuric acid diluted with water, produce 312½ pounds of crystallized sulphate of copper. A leaden boiler is best adapted for that operation. 100 pounds of silver are precipitable from its solution in nitric acid, by 29 of copper. If more be needed, it is a proof that a wasteful excess of acid has existed in the solution.

In parting by nitric acid, the gold generally retains a little silver; as is proved by the cloud of chloride of silver which it affords, at the end of some hours, when dissolved in aqua regia. And on the other hand, the silver retains a little gold. These facts induced M. Dizé, when he was inspector of the French mint, to adopt some other process, which would give more accurate analytical results; and after numerous experiments, he ascertained that sulphuric acid presented great advantages in this point of view, since with it he succeeded in detecting, in silver, quantities of gold which had eluded the other plan of parting. The suggestion of M. Dizé has been since universally adopted in France. M. Costell, about nine or ten years ago, erected in Pomeroy-street, Old Kent-road, a laboratory upon the French plan, for parting by sulphuric acid; but he was not successful in his enterprise; and since he relinquished the business, Mr. Matheson introduced the same system into our Royal Mint, under the management of M. Costell's French operatives. In the Parisian refineries, gold, to the amount of one thousandth part of the weight, has been extracted from all the silver which had been previously parted by the nitric acid process; being 3500 francs in value upon every thousand kilogrammes of silver.

I shall give first a general outline of the method of parting by sulphuric acid, and then describe its details as I have lately seen them executed upon a magnificent scale in an establishment near Paris.

The most suitable alloy for refining gold, by the sulphuric acid process, is the compound of gold, silver, and copper, having a standard quality, by the cupel, of from 900 to 950 milliêmes, and containing one fifth of its weight of gold. The best proportions of the three metals are the following:—silver, 725; gold, 200; copper, 75; = 1000. It has been found that alloys which contain more copper, afford solutions that hold some anhydrous sulphate of that metal in solution, which prevents the gold from being readily separated; and that alloys containing more gold, are not acted on easily by the sulphuric acid. The refiner ought, therefore, when at all convenient, to reduce the alloys that he has to treat to the above-stated proportions. He may effect this purpose either by fusing the coarser alloys with nitre in a crucible, or by adding finer alloy, or even fine silver, or finally, by subjecting the coarser alloys to a previous cupellation with lead on the great scale. As to gold or silver bullion, which contains lead and other easily oxydizable metals besides copper, the refiner ought always to avoid treating them by sulphuric acid; and should separate, first of all, these foreign metals by the agency of nitre, if they exist in minute quantity; but if in larger, he should have recourse to the cupel. Great advantage will therefore be derived from the judicious preparation of the alloy to be refined.

For an alloy of the above description, the principal Parisian refiners are in the habit of employing thrice its weight of sulphuric acid, in order to obtain a clear solution of sulphate of silver, which does not too suddenly concrete on cooling, so as to obstruct its discharge from the alembic by decantation. A small increase in the quantity of copper, calls for a considerable increase in the quantity of acid.

Generally speaking, one half of the sulphuric acid strictly required for converting the silver and copper into sulphates, is decomposed into sulphurous acid, which is lost to the manufacturer, unless he has recourse to the agency of nitrous acid.

The process for silver containing but little gold, consists of five different operations.

1. Upon several furnaces, one foot in diameter, egg-shaped alembics of platinum are mounted, into each of which are put 3 kilogrammes (8 lbs. troy) of the granulated silver, containing a few grains of gold per pound, and 6 kilogrammes of concentrated sulphuric acid. The alembics are covered with conical capitals, ending in bent tubes, which conduct the acid vapors into lead pipes of condensation; and the furnaces are erected under a proper hood. As the cold acid is inoperative, it must be set a boiling, at which temperature it gives up one atom of its oxygen to the metal, and is transformed into sulphurous acid, which escapes in a gaseous state. Some of the undecomposed sulphuric acid immediately combines with the oxyde into a sulphate, which subsides, in the state of a crystalline powder, to the bottom of the vessel. The solution goes on vigorously, with a copious disengagement of sulphurous acid gas, only during the two or three first hours; after which it proceeds slowly, and is not completed till after a digestion of nearly twelve hours more. During the ebullition a considerable quantity of sulphuric acid vapor escapes along with the sulphurous acid gas; the former of which is readily condensed in a large leaden receiver immersed in a cistern of cold water, if need be. It has been proposed to condense the sulphurous acid, by leading it over extensive surfaces of lime-pap, as in the coal-gas purifiers.

2. When the whole silver has been converted into sulphate, this is to be emptied out of the alembic into water contained in a round-bottomed receiver lined with lead, and diluted till the density of the solution marks from 15° to 20° Baumé. The small portion of gold, in the form of a brown powder, which remains undissolved, having been allowed to settle to the bottom, the supernatant solution of silver is to be decanted carefully off into a leaden cistern, and the powder being repeatedly edulcorated with water, the washings are to be added to it. The silver is now to be precipitated by plunging plates of copper in the solution, and the magma which falls is to be well washed, and freed from the residuary particles of sulphate of copper by powerful compression.

3. The silver, precipitated and dried as above described, is melted in a crucible, and cast into an ingot.

4. The gold powder is also dried and cast into an ingot, a little nitre being added in the fusion, to oxydize and separate any minute particles of copper that may perchance have been protected from the solvent action of the acid.

5. As the sulphate of copper is of considerable value, its solution is to be neutralised, evaporated in leaden pans to a proper strength, and set aside to crystallize in leaden cisterns. The farmers throughout France consume an immense quantity of this salt. They sprinkle a weak solution of it (at 2° or 3° Baumé) over their grain before sowing it, in order to protect it against the ravages of birds and insects.

The pure gold, at the instant of its separation from the alloy by the action of sulphuric acid, being in a very fine powder, and lying in close contact with the platinum, under the influence of a boiling menstruum, which brightens the surfaces of the two metals, and raises their temperature to fully the 600th degree of Fahrenheit's scale, tends to become partially soldered to the platinum, and may thus progressively thicken the bottom of the still. The importance of preserving this vessel entire, and of economizing the fuel requisite to heat its contents, induces the refiner to detach the crust of gold from time to time, by passing over the bottom of the still, in small quantities, a dilute nitro-muriatic acid, which acts readily on gold, but not on platinum. But as this operation is a very delicate one, it must be conducted with great circumspection. The danger of such adhering deposites is much increased by using too high a heat, and too small a body of acid, relatively to the metals dissolved. Hence it is advantageous to employ alembics of large size. Should any lead or tin get into the platinum still, while the hot acid is in it, the precious vessel would be speedily destroyed; an accident which has not unfrequently happened. Each operation may be conveniently finished in twelve hours;

so that each alembic may refine with ease 160 marcs daily. Some persons work more rapidly, but such haste is hazardous.

The Parisian refiners restore to the owners the whole of the gold and silver contained in the ingots, reserving to themselves the copper which formed the alloy, and charging only the sum of 5½ francs per kilogramme (2·68 lbs. troy) for the expense of the parting of the metals.

If they are employed to refine an ingot of silver containing less than one tenth of gold, they retain for themselves a two thousandth part of the gold, and all the copper, existing in the alloy; return all the rest of the gold, with the whole of the silver, in the ingot; and give, besides, to the owners a *premium* or *bonus*, which amounted lately to ¾ of a franc on the kilogramme of metal. Should the owner desire to have the whole of the gold and silver contained in his ingot, the refiner then demands from him 2 francs and 68 centimes per kilogramme, retaining the copper of the alloy. As to silver ingots of low standard, the perfection of the refining processes is such, that the mere copper contained in them pays all the costs; for in this case, the refiner restores to the proprietor of the ingot as much fine silver as the assay indicated to exist in the ingot, contenting himself with the copper of the alloy. See *infrà*.

The chemical works of M. Poizat, called *affinage d'argent*, on the bank of the *canal de l'Ourcq*, in the vicinity of Paris, are undoubtedly the most spacious and best arranged for refining the precious metals, which exist in the world. On being introduced to this gentleman, by my friend and companion M. Clement-Desormes, he immediately expressed his readiness to conduct me through his *fabrique*, politely alluding to the French translation of my Dictionary of Chemistry, which lay upon the desk of his *bureau*. The principal room is 240 feet long, 40 feet wide, and about 30 feet high. A lofty chimney rises up through the middle of the apartment, and another at each of its ends. The one space, 120 feet long, to the right of the central chimney, is allotted to the processes of dissolving the silver, and parting the gold; the other, to the left, to the evaporation and crystallization of the sulphate of copper, and the concentration of the recovered sulphuric acid.

M. Poizat melts his great masses of silver in pots made of malleable iron, capable of holding several cwts. each; and granulates it by pouring it into water contained in large iron pans. The granulated silver is dried with heat, and carried into a well lighted office enclosed by glazed casements, to be weighed, registered, and divided into determinate portions. Each of these is put into a cast-iron pot, of a flattened hemispherical shape, about 2 feet in diameter, covered with an iron lid, made in halves, and hinged together in the middle line. From the top of the fixed lid a bent pipe issues, and proceeds downwards into an oblong leaden chest sunk beneath the floor. Four of the above cast-iron pots stand in a line across the room, divided into two ranges, with an intervening space for passing between them. The bottoms of the pots are directly heated by the flame, one fire serving for two pots. Two parts of concentrated sulphuric acid by weight are poured upon every part of granulated silver, and kept gently boiling till the whole silver be converted into a pasty sulphate.

From the underground leaden chests, a leaden, pipe 4 inches in diameter, rises vertically, and enters the side of a leaden chamber, which is supported upon strong cross-beams or rafters, a little way beneath the roof of the apartment. This chamber, which is 30 feet long, 10 feet wide, and 6 feet high, is intended to condense the sulphuric acid vapors, along with some of the sulphurous acid; that of the latter being promoted by the admission of nitrous gas and air, which convert it into sulphuric acid. From the further end of this chamber, a large square leaden pipe returns with a slight slope towards the middle of the room, and terminates at the right-hand side of the central chimney, in a small leaden chest, for receiving the drops of acid which are condensed in the pipe. From that chest a pipe issues, to discharge into the high central chimney the incondensable gases, and also to maintain a constant draught through the whole series of leaden chambers back to the cast-iron hemispherical pots.

Besides the above cast-iron pots, destined to dissolve only the coarse cupreous silver, containing a few grains of gold per pound, there are, in the centre of the apartment, at the right-hand side of the chimney, 6 alembics of platinum, in which the rich alloys of gold and silver are treated in the process of refining gold.

The pasty sulphate of silver obtained in the iron pots, is transferred by cast-iron ladles with long handles into large leaden cisterns, adjoining the pots, and there diluted with a little water to the density of 36° Baumé. Into this liquor, steam is admitted through a series of upright leaden pipes arranged along the side of the cistern, which speedily causes ebullition, and dilutes the solution eventually to the 22d degree of Baumé. In this state, the liquid supersulphate is run off by leaden syphons into large oblong leaden cisterns, rounded at the bottom; and is there exposed to the action of ribands of copper, like thin wood shavings. The metallic silver precipitates in a pasty form; and the supernatant sulphate of copper is then run off into a cistern, upon a somewhat lower level, where it is left to settle and become clear.

The precipitate of silver, called by the English, water-silver, and by the French, *chaux d'argent*, is drained, then strongly squeezed in a square box of cast-iron, by the action of a hydraulic press; in which 60 pounds of silver are operated upon at once.

The silver lumps are dried, melted in black lead crucibles, in a furnace built near the silver end of the room, where the superintendent sits in his *bureau*—a closet enclosed by glazed casements, like a green-house. The whole course of the operations is so planned, that they are made to commence near the centre with the mixed metals, and progressively approach towards the office end of the apartment as the parting processes advance. Here the raw material, after being granulated and weighed, was given out, and here the pure gold and silver are finally eliminated in a separate state.

In the other half of the hall, the solutions of sulphate of copper are evaporated in large shallow leaden pans, placed over a range of furnaces; from which, at the proper degree of concentration, they are run off by syphons into crystallizing pans of the same metal. From the mother-waters, duly evaporated, a second crop of crystals is obtained; and also a third, the last being anhydrous, from the great affinity for water possessed by the strong sulphuric acid with which they are now surrounded. The acid in this way parts with almost the whole of the cupreous oxyde, and is then transferred into a large alembic of platinum (value 1000*l.*), to be rendered fit, by re-concentration, for acting upon fresh portions of granulated silver. The capital of that alembic is connected with a leaden worm, which traverses an oblong vessel, through which a stream of cold water flows.

The crystallized sulphate of copper fetched, two years ago, 30*l.* a ton. It is almost all sold to the grocers in the towns of the agricultural districts of France. In the above establishment of M. Poizat, silver to the value of 10,000*l.* can be operated upon daily.

There is a steam engine of 6-horse power placed in a small glazed chamber at one side of the parting hall, which serves to work all his leaden pumps for lifting the dilute sulphuric acid and acidulous solutions of copper into their appropriate cisterns of concentration, as also to grind his old crucibles, and drive his amalgamation mill, consisting of a pair of vertical round-edged wheels, working upon one shaft, in a groove formed round a central hemisphere—of cast-iron. After the mercury has dissolved out of the ground crucibles all the particles of silver which it can find, the residuary earthy matter is sold to the *sweep-washers*. The floor of the hall around the alembics, pots, and cisterns, is covered with an iron grating, made of bars having one of their angles uppermost, to act as scrapers upon the shoes of the operatives. The dust collects in a vacant space left beneath the grating, whence it is taken to the amalgamation mill. The processes are so well arranged and conducted by M. Poizat, that he can execute as much business in his establishment with 10 workmen as is elsewhere done with from 40 to 50; and with less than 3 grains of gold, in one Paris pound or 7561 grains of silver, he can defray the whole expenses of the parting or refining.

Since 26 parts of copper afford 100 of the crystallized sulphate, the tenth of copper present in the dollars, and most foreign coins, will yield nearly four times its weight of blue vitriol; a subsidiary product of considerable value to the refiner.

The works of M. Poizat are so judiciously fitted up as to be quite salubrious, and have not those "very mischievous effects upon the trachea," which Mr. Matheson states as being common in his refinery works in the Royal Mint.* But, in fact, as refining by sulphuric acid is always a nuisance to a neighborhood, it is not suffered in the *Monnaie Royale* of Paris; but is best and most economically performed by private enterprise and fair competition, which is impossible in London, on account of the anomalous privilege, worth at least 2000*l.* a year, possessed by Mr. Matheson, who works most extensively for private profit on a public plant, fitted up with a lofty chimney, platinum vessels to the value of 3000*l.*, and other apparatus, at the cost of the government. His charge to the crown for refining gold per lb. troy, is 6*s.* 6*d.*; that of the refiners in London, who are obliged, for fear of prosecution, to employ the more expensive, but more condensable, nitric acid, is only 4*s.* That of the Parisian refiners is regulated as follows. For the dealers in the precious metals:—

For gold bullion containing silver, and more than $\frac{100}{1000}$ of gold, 6 fr. 12 c. per kilogramme, = 2 fr. 29 c. per lb. troy.

For silver bullion, containing from $\frac{1}{1000}$ to $\frac{100}{1000}$ of gold (called *dorés*), 3 fr. 27 c. per kilogramme, = 1 fr. 22 c. per lb. troy.

For the *Monnaie*, the charges are—

For gold refined by sulphuric acid, when alloyed with copper only, from $\frac{898}{1000}$ to $\frac{1}{1000}$, 5 fr. per kilogramme, = 1 fr. 86 c. per lb. troy.

For gold alloyed with copper and silver, whatever be the quantity of silver, 5 fr. 75 c. per kilogramme, = 2 fr. 12 c. per lb. troy.

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* Report of Committee of House of Commons on the Mint, in 1837, p. 91.

are about ten bullion refiners by sulphuric acid in the environs of Paris; two of . Poizat St. André, and M. Chauvière, are by far the most considerable; the orking about 300 kilogrammes (= 804 lbs. troy) daily, and the latter about two that quantity. In former times, when competition was open in London, Messrs. and Brinde were wont to treat 6 cwts. of silver, or 9 cwts. of gold alloy, daily, l months in succession.

sult of *free trade* in refining bullion at Paris is, that the silver bars imported lon from South America, &c., are mostly sent off to Paris to be stripped of the is of gold which they may contain, and are then brought back to be sold here. ains of gold in one Paris lb. of silver, pay the refiners there for taking them hat a disgrace is thus brought upon our manufacturing industry and skill, by poly charges in refining and assaying granted to two individuals in our Royal

ingley's charges for assaying at the Royal Mint in London, are—

assay of gold, 4*s.*; for a parting assay of gold and silver, 6*s.*; for a silver assay, charges which absorb the profits of many a transaction.

harges at the Royal Mint of Paris, for assays made under the following distin- hemical *savants*—Darcet, *Directeur*; Bréant, *Verificateur;* Chevillot and Pelouze, *s*; are—

. assay of gold, or *doré* (a parting assay), 3 francs.

— silver — — 0· 80 c. = 8*d.* English.

y Lussac is the assayer of the *Bureau de Garantie* at the *Monnaie Royale*, an hich corresponds to the Goldsmiths' Hall at London. The silver assays in all al establishments of Europe, except the two in London, are made by the *humid* and are free from those errors and blunders which daily annoy and despoil the ullion merchant, who is compelled by the Mint and Bank of England to buy and e *cupellation* assay of Mr. Bingley. See ASSAY and SILVER.

IGERATION OF WORTS, &c. In August, 1826, Mr. Yandall obtained for an apparatus designed for cooling worts and other hot fluids, without them to evaporation. Utensils employed for this purpose, are generally called tors, and are so constructed, that a quantity of cold water shall be brought in with the vessel which contains the heated fluid. But in every construction of tor heretofore used, the quantity of cold water necessarily employed in the ı, greatly exceeded the quantity of the fluid cooled, which, in some situations, ater cannot be readily obtained, was a serious impediment and objection to the ich apparatus.

ıventor has contrived a mode of constructing a refrigerator, so that any quantity r other hot fluid may be cooled by an equal quantity of cool water; the process formed with great expedition, simply by passing the two fluids through very nar- ages, in opposite directions, the result of which is, that the cold liquor imbibes from the wort, or other fluid, and the temperature of the hot fluid is reduced in ratio.

932, 933, and 934 represent different forms in which the apparatus is proposed to . The two first have zigzag passages; the third, channels running in convolute These channels or passages are of very small capacity in thickness, but of great ınd of any breadth that may be required, according to the quantity of fluid in- o be cooled or heated.

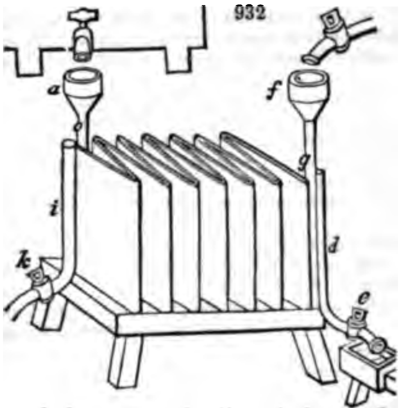
35 is the section of a portion of the apparatus shown at *figs.* 932 and 933 upon ged scale; it is made by connecting three sheets of copper or any other thin me- ates together, leaving parallel spaces between each plate for the passage of the epresented by the black lines.

spaces are formed by occasionally introducing between the plates thin straps, portions of metal, by which means very thin channels are produced, and through annels the fluids are intended to be passed, the cold liquor running in one direc- d the hot in the reverse direction.

sing that the passages for the fluids are each one eighth of an inch thick, then re length for the run of the fluid should be about 80 feet, the breadth of the ap- being made according to the quantity of fluid intended to be passed through it in time. If the channels are made a quarter of an inch thick, then their length e extended to 160 feet; and any other dimensions in similar proportions; but a hannel than one quarter of an inch, the patentee considers would be objectionable. wever, to be observed, that the length here recommended, is under the considera- t the fluids are driven through the apparatus by some degree of hydrostatic pres- m a head in the delivery-vats above; but if the fluids flow without pressure, then ths of the passages need not be quite so great.

e apparatus constructed as shown in perspective at *fig.* 932, and further developed by the section, *fig.* 935, cold water is to be introduced at the funnel *a*, whence it passes down the pipe *b*, and through a long slit or opening in the side of the pipe, into the passage *c*, *c* (see *fig.* 935), between the plates, where it flows in a horizontal direction through the channel towards the discharge-pipe *d*. When such a quantity of cold water has passed through the funnel *a*, as shall have filled the channel *c*, *c*, up to the level of the top of the apparatus, the cock *e* being shut, then the hot wort or liquor intended to be cooled, may be introduced at the funnel *f*, and which, descending in the pipe *g*, passes in a similar manner to the former, through a long slit or opening in the side of the pipe *g*, into the extended passage *h*, *h* (see *fig.* 935), and from thence proceeds horizontally into the discharge-pipe *i*.

932

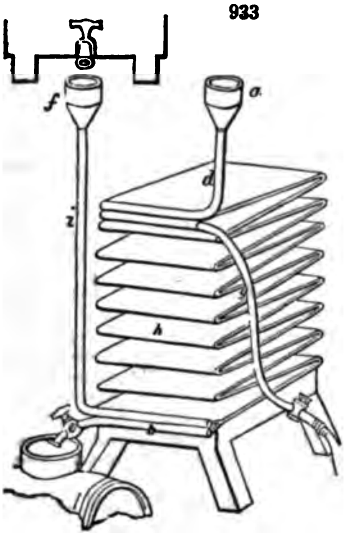


The two cocks *e* and *k*, being now opened, the wort or other liquor is drawn off, or otherwise conducted away through the cock *k*, and the water through *e*. If the apertures of the two cocks *e* and *k* are equal, and the channels equal also, it follows that the same quantity of wort, &c., will flow through the channel *h*, *h*, *h*, in a given time, as of water through the channel *c*, *c*; and by the hot fluid passing through the apertures in contact with the side of the channel which contains the cold fluid, the heat becomes abstracted from the former, and communicated to the latter; and as the hot fluid enters the apparatus at that part which is in immediate contact with the part where the cooling fluid is discharged, and the cold fluid enters the apparatus at that part where the wort is discharged, the consequence is, that the wort or other hot liquor becomes cooled down towards its exit-pipe nearly to the temperature of cold water; and the temperature of the water, at the reverse end of the apparatus, becomes raised nearly to that of the boiling wort.

It only remains to observe, that by partially closing either of the exit-cocks, the quantity of heat abstracted from one fluid, and communicated to the other, may be regulated; for instance, if the cock *e* of the water-passage be partially closed, so as to diminish the quantity of cold water passed through the apparatus, the wort or other hot fluid conducted through the other passages will be discharged at a higher temperature, which in some cases will be desirable, when the refrigerated liquor is to be fermented.

Fig. 933 exhibits an apparatus precisely similar to the foregoing, but different in its position; for instance, the zigzag channels are made in obliquely descending planes. *a* is the funnel for the hot liquor, whence it descends through the pipe *d* into the channel *c*, *c* (see *fig.* 935), and ultimately is discharged through the pipe *b*, at the cock *e*. The cold water being introduced into the funnel *f*, and passing down the pipe *i*, enters the zigzag channel *h*, *h*, and, rising through the apparatus, runs off by the pipe *g*, and is discharged at the cock below.

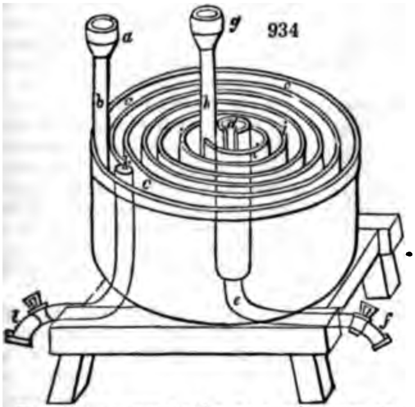
933



The passages of this apparatus for heating and cooling fluids, may be bent into various contorted figures; one form found particularly convenient under some applications, is that represented at *fig.* 934, which is contained in a cylindrical case. The passages here run in convolute curves, the one winding in a spiral to the centre, the other receding from the centre.

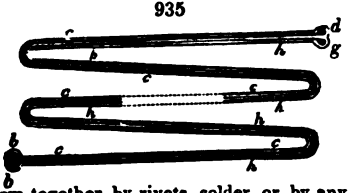
The wort or other hot liquor intended to be cooled, is to be introduced at the funnel *a*, and passing down the pipe *b*, is delivered into the open passage *c*, which winds round to the central chamber *d*, and is thence discharged through the pipe *e*, at the cock *f*. The cold water enters the apparatus at the funnel *g*, and proceeding down the pipe *h*, enters the closed channel *i*, and after traversing round through the apparatus, is in like manner discharged through the pipe *k*, at the cock *l*. Or the hot liquor may be passed through the closed channel, and the cold through the open one; or these chambers may be both of them open at top, and the apparatus covered by a lid when at work, the principal design of which is to afford the convenience of cleaning them more readily than could be done if they were closed; or they may be both closed.

934



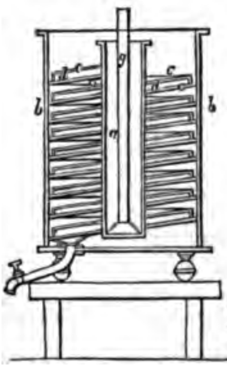
A similar ingenious apparatus for cooling brewer's worts, or wash for distillers, and also for condensing spirits, in place of the ordinary worm tub, is called by the inventor, Mr. Wheeler, an Archimedes condenser, or refrigerator, the peculiar novelty of which consists in forming the chambers for the passage of the fluids in spiral channels, winding round a central tube, through which spiral channels the hot and cold fluids are to be passed in opposite directions. *Fig.* 936 represents the external appearance of the refrigerator, enclosed in a cylindrical case; *fig.* 937, the same, one half of the case being removed to show the form of the apparatus within; and *fig.* 938, a section cut through the middle of the apparatus perpendicularly, for the purpose of displaying the internal figure of the spiral channels.

935

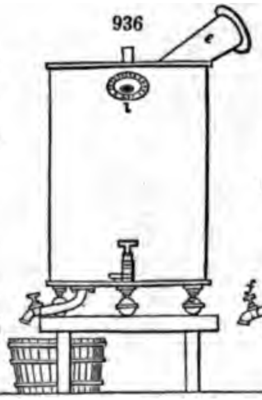


The apparatus is proposed to be made of sheet copper, tinned on its surface, and is formed by cutting circular pieces of thin copper, or segments of circles, and connecting them together by rivets, solder, or by any other convenient means, as coppersmiths usually do; these circular pieces of copper being united to one another, in the way of a spiral or screw, form the chambers through which the fluids are to pass within, in an ascending or descending inclined plane.

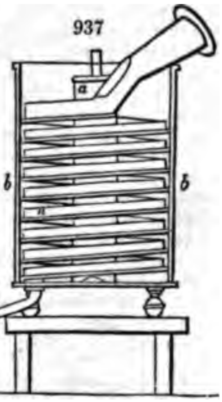
938



936



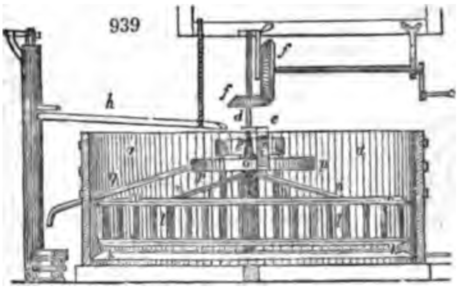
937



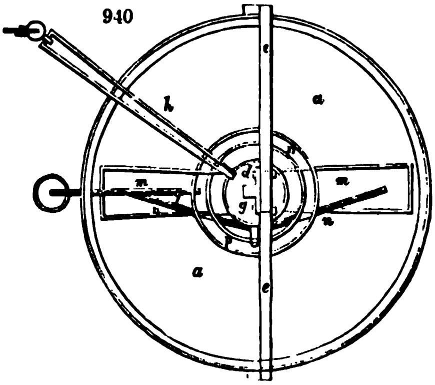
In *figs.* 937 and 938, *a*, *a*, is the central tube or standard (of any diameter that may be found convenient), round which the spiral chambers are to be formed; *b*, *b*, are the sides of the outer case, to which the edges of the spiral fit closely, but need not be attached; *c*, *c*, are two of the circular plates of copper, connected together by rivets at the edges, in the manner shown, or by any other suitable means; *d*, is the chamber, formed by the two sheets of copper, and which is carried round from top to bottom in a spiral or circular inclined plane, by a succession of circular plates connected to each other.

The hot fluid is admitted into the spiral chamber *d*, through a trumpet or wide-mouthed tube *e*, at top, and is discharged at bottom by an aperture and cock *f*. The cold water which is to be employed as the cooling material, is to be introduced through the pipe *g*, in the centre, from whence discharging itself by a hole at bottom, the cold water occupies the interior of the cylindrical case *b*, and rises in the spiral passage *h*, between the coils of the chamber, until it ascends to the top of the vessel, and then it flows away by a spout *i*, seen in *fig.* 936.

939



940



It will be perceived that the hot fluid enters the apparatus at top, and the cold fluid at bottom, passing each other, by means of which an interchange of temperatures takes place through the plates of copper, the cooling fluid passing off at top in a heated state, by means of the caloric which it has abstracted from the hot fluid; and the hot fluid passing off through the pipe and cock at bottom, in a very reduced state of temperature, by reason of the caloric which it held having been given out to the cooling fluid.

Fig. 939 is a side view and section of Wagenmann's apparatus for cooling worts; *fig.* 940, a view from above. The preceding contrivances seem to be far preferable.

a, *a*, is the tub for receiving the apparatus, whose central upright shaft *b*, rests upon a step *c*, in the bottom, and revolves at top in a bush at *d*, made fast to a bar *e*, fixed fast across the mouth of the tub. The shaft may be driven by the two bevel wheels *f*, *f*, at right angles to each other, and the horizontal rod turned by hand; or the whole may be impelled by any power. *g*, is an iron basin for receiving the cold water from the spout *h*, supplied by a well; it flows out of the basin through two tubes *i i*, down into the lower part of the cooler *k k*. The cooler consists of two flat vessels, both of which are formed of a flat interior plate, and an arched exterior one, so that their transverse section is plano-convex. The water which flows along the tubes *i i*, spreads itself upon the bottom of the cooler, and then rises through the scabbard-shaped tubes *l l*, &c., into the upper annular vessel *m m*; whence it is urged by hydrostatic pressure, in a now heated state, through the slanting tubes *n n*, which terminate in the common pipe *o*, of the annular basin *p p*, and is thence discharged by the pipe *q*. The basin *p p*, is supported by the two bearers *r*, made fast to the cross-beam *e*. There is in the lowest part of the hollow ring at bottom, a screw plug, which may be opened when it is desired to discharge the whole contents, and to wash it with a stream of water.

REGULUS is a term introduced by the alchemists, now nearly obsolete. It means literally a little king, and refers to the metallic state as one of royalty, compared with the native earthy condition. Antimony is the only metal now known by the name of regulus.

RESINS (*Résines*, Fr.; *Harze*, Germ.), are proximate principles found in most vegetables, and in almost every part of them; but the only resins which merit a particular description, are those which occur naturally in such quantities as to be easily collected or extracted. They are obtained chiefly in two ways, either by spontaneous exudation from the plants, or by extraction by heat and alcohol. In the first case, the discharge of resin in the liquid state is sometimes promoted by artificial incisions made in summer through the bark into the wood of the tree.

Resins possess the following general properties:—They are soluble in alcohol, insoluble in water, and melt by the application of heat, but do not volatilize without partial decomposition. They have rarely a crystalline structure, but, like gums, they seldom affect any peculiar form. They are almost all translucid, not often colorless, but generally brown, occasionally red or green. Any remarkable taste or smell which they sometimes possess, may be ascribed to some foreign matter, commonly an essential oil. Their specific gravity varies from 0·92 to 1·2. Their consistence is also very variable. The greater part are hard, with a vitreous fracture, and so brittle as to be readily pulverized in the coal. Some of them are soft, a circumstance probably dependant upon the presence of a heterogeneous substance. The hard resins do not conduct electricity, and they become negatively electrical by friction. When heated, they melt more or less easily into a thick viscid liquid, and concrete, on cooling, into a smooth shining mass, of a vitreous fracture, which occasionally flies off into pieces, like Prince Rupert's drops; especially after being quickly cooled, and scratched with a sharp point. They take fire by contact of an ignited body, and burn with a bright flame, and the diffusion of much sooty smoke. When distilled by themselves in close vessels, they afford carbonic acid and carbureted gases, empyreumatic oil of a less disagreeable smell than that emitted by other such oils, a little acidulous water, and a very little shining charcoal. See Rosin Gas.

Resins are insoluble in water, but dissolve in considerable quantities in alcohol, both hot and cold. This solution reddens tincture of litmus, but not sirup of violets; it is decomposed by water, and a milkiness ensues, out of which the particles of the resin gradually agglomerate. In this state it contains water, so as to be soft, and easily kneaded between the fingers; but it becomes hard and brittle again when freed by fusion from the water. The resins dissolve in ether and the volatile oils, and, with the aid of heat, combine with the unctuous oils. They may be combined by fusion with sulphur, and with a little phosphorus. Chlorine water bleaches several colored resins, if they be diffused in a milky state through water. The carburet of sulphur dissolves them.

Resins are little acted upon by acids, except by the nitric, which converts them into artificial tan. They combine readily with the alkalis and alkaline earths, and form what were formerly reckoned soaps: but the resins are not truly saponified; they rather represent the acid constitution themselves, and, as such, saturate the salifiable bases.

Every resin is a natural mixture of several other resins, as is the case also with oils; one principle being soluble in cold alcohol, another in hot, a third in ether, a fourth in oil of turpentine, a fifth in naptha, &c. The soft resins, which retain a certain portion of volatile oil, constitute what are called balsams. Certain other balsams contain benzoic acid. The solid resins are, *amber*, *anime*, *benzoin*, *colophony* (common rosin), *copal*, *dammara*, *dragon's blood*, *elemi*, *guaiac*, *lac*, resin of *jalap*, *ladanum*, *mastic*, *sandarach*, *storax*, *takamahac*.

RESIN, KAURI or COWDEE, is a new and very peculiar substance, recently imported in considerable quantities from New Zealand, which promises to be useful in the arts. It oozes from the trunk of a noble tree called *Dammara australis*, or *Pinus kauri*, which rises sometimes to the height of 90 feet without a branch, with a diameter of 12 feet, and furnishes a log of heart timber of 11 feet. The resin, which is called Cowdee gum by the importers, is brought to us in pieces varying in size from that of a nutmeg to a block of 2 or 3 cwts. The color varies from milk-white to amber, or even deep brown; some pieces are transparent and colorless. In hardness it is intermediate between copal and resin. The white milky pieces are somewhat fragrant, like elemi. Specific gravity, 1·04 to 1·06. It is very inflammable, burns all away with a clear bright flame, but does not drop. When cautiously fused, it concretes into a transparent hard tough mass, like shellac. It affords a fine varnish with alcohol, being harder and less colored than mastic, while it is as soluble, and may be had probably at one tenth of the price. A solution in alcohol, mixed with one fourth of its bulk of a solution in oil of turpentine, forms an excellent varnish, which dries quickly, is quite colorless, clear and hard. It is insoluble in pyro-acetic (pyroxilic?) spirit. Combined with shellac and turpentine, it forms a good sealing-wax.

REVERBERATORY FURNACE; see Copper, Iron, and Soda.

RETORT. For producing coal gas, there are many modifications, varying in dimension and shape with the caprice of the constructor, and in many cases without any definite idea of the principle to be aimed at.

They may be divided into three general classes:

1st. The circular retort, from twelve to twenty inches in diameter, and from six to nine feet in length. This retort is used in Manchester and some other places, in general for the distillation of cannel, or Scotch parrot coal. It answers for the distillation of a coal which retains its form in lumps, and is advantageous only from the facility with which its position is changed, when partially destroyed by the action of fire on the under side.

2d. The small or London D retort, so called in consequence of its having first been used by the chartered company in London, being still in use at their works, and recommended by their engineer. This retort is 12 inches broad on the base, 11 inches high, and 7 feet long, carbonizing one and a half to two bushels at a charge.

3d. The York D retort, (so called in consequence of its having been introduced by Mr. Outhit, of York,) and the modifications of it, among which I should include the elliptic retort, as having the same general purpose in view. The difference between the London and York D retorts, consists only in an extension of surface upon which the coal is spread. See GAS-LIGHT.

RHODIUM, is a metal discovered by Dr. Wollaston in 1803, in the ore of platinum. It is contained to the amount of three per cent. in the platinum ore of Antioquia in Colombia, near Barbacoas; it occurs in the Ural ore, and, alloyed with gold, in Mexico. The palladium having been precipitated from the muriatic solution of the platinum ore previously saturated with soda, by the cyanide of mercury, muriatic acid is to be poured into the residuary liquid, and the mixture is to be evaporated to dryness, to expel the hydrocyanic acid, and convert the metallic salts into chlorides. The dry mass is to be reduced to a very fine powder, and washed with alcohol of specific gravity 0·837. This solvent takes possession of the double chlorides which the sodium forms with the platinum, iridium, copper, and mercury, and does not dissolve the double chloride of rhodium and sodium, but leaves it in the form of a powder, of a fine dark-red color. This salt being washed with alcohol, and then exposed to a very strong heat, affords the rhodium. But a better mode of reducing the metal upon the small scale, consists in heating the double chloride gently in a glass tube, while a stream of hydrogen passes over it, and then to wash away the chloride of sodium with water.

Rhodium resembles platinum in appearance. Any heat which can be produced in a chemical furnace is incapable of fusing it; and the only way of giving it cohesive solidity, is to calcine the sulphuret or arseniuret of rhodium in an open vessel at a white heat, till all the sulphur or arsenic be expelled. A button may thus be obtained, somewhat spongy, having the color and lustre of silver. According to Wollaston, the specific gravity of rhodium is 11. It is insoluble by itself in any acid; but when an alloy of it with certain metals, as platinum, copper, bismuth, or lead, is treated with aqua regia, the rhodium dissolves along with the other metals; but when alloyed with gold or silver it will not dissolve along with them. It may, however, be rendered very soluble by mixing it in the state of a fine powder with chloride of potassium or sodium, and heating the mixture to a dull-red heat, in a stream of chlorine gas. It thus forms a triple salt, very soluble in water. The solutions of rhodium are of a beautiful rose color, whence its name. In the dry way, it dissolves by heat in bisulphate of potassa; and disengages sulphurous acid gas in the act of solution. There are two oxydes of rhodium. Rhodium combines with almost all the metals; and, in small quantity, melted with steel, it has been supposed to improve the hardness, closeness, and toughness of this metal. Its chief use at present is for making the inalterable nibs of the so-named rhodium pens.

RIBAND MANUFACTURE, is a modification of WEAVING, which see.

RICE, of Carolina, analyzed by Braconnot, was found to be composed of starch 85·07, of gluten 3·60, of gum 0·71, of uncrystallizable sugar 0·29, of a colorless rancid fat like suet 0·13, of vegetable fibre 4·8, of salts with potash and lime bases 0·4, and 5·0 of water.

The quantity of rice entered for home consumption in the year 1836, was—

Cwts. 81,610. In 1837, 126,739.
Ditto in the husk, Bushels 292,411. 282,377.

Rice Paper, as it is called, on which the Chinese and Hindoos paint flowers so prettily, is a membrane of the bread-fruit tree, the *Artocarpus incisifolia* of naturalists.

RICE CLEANING. Various machines have been contrived for effecting this purpose, of which the following, secured by patent to Mr. Melvil Wilson, in 1826, may be regarded as a good specimen. It consists of an oblong hollow cylinder, laid in an inclined position, having a great many teeth stuck in its internal surface, and a central shaft also furnished with teeth. By the rapid revolution of the shaft, its teeth are carried across the intervals of those of the cylinder with the effect of parting the grains of rice, and detaching whatever husks or impurities may adhere to them. A hopper is set above to receive the rice, and conduct it down into the cleansing cylinder.

About 80 teeth are supposed to be set in the cylinder, projecting so as to reach very nearly the central shaft; in which there is a corresponding number of teeth, that pass freely between the former.

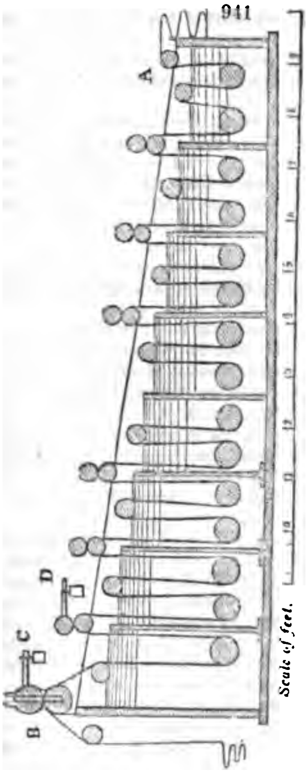
The cylinder is shown inclined in the figure which accompanies the specification; but it may be placed also upright or horizontal, and may be mounted in any convenient frame-work. The central shaft should be put in rapid rotation, while the cylinder receives a slow motion in the opposite direction. The rice, as cleaned by that action, is discharged at the lower end of the cylinder, where it falls into a shute (shoot), and is conducted to the ground. The machine may be driven by hand, or by any other convenient power.

Rice consists chiefly of starch, and therefore cannot by itself make a proper bread. It is used in the cotton factories to form weavers' dressings for warps. The Chinese reduce its flour into a pulp with hot water, and mould it into figures and plates, which they afterwards harden, and ornament with engravings, resembling those of mother-of-pearl. When a decoction of rice is fermented and distilled, it affords the sort of ardent spirit called *arrack* in the East Indies.

RIFLE; see FIRE-ARMS.

RINSING MACHINE is one of those ingenious automatic contrivances for economizing labor, and securing uniformity of action, now so common in the factories of Lancashire. *Fig.* 941 is a longitudinal middle section of an approved mechanism for rinsing pieces of calico dyed with spirit or fancy colors, and which require more delicate treatment than is compatible with hand-washing. A, E, F, B, is a wooden cistern, about 12 feet long, 4 feet high at one end, 2 feet at the other, and of the ordinary width of calico cloth. It is divided transversely into a series of equal compartments by partitions, decreasing in height from the upper to the lower end, the top of each of them, however, being an inch at least under the top of the enclosing side at its line of junction. Above the highest end of the trough, a pair of squeezing rollers is mounted at B; the lower one having a pulley upon the end of its shaft, for turning it, by means of a band from one of the driving-shafts of the factory; and the upper one is pressed down upon it by weighted levers acting on the ends of its axis. The roller above the second highest partition has also a pair of squeezing rollers, with a weighted lever D. The pieces of cloth, stitched endwise, being laid upon a platform to the right hand of the cistern, are introduced over the roller A, passed down under the roller beneath it, and so up and down in a serpent-like path, from the lowest compartment of the cistern to the uppermost, being drawn through the series by the traction of the rotatory roller at B. While the long web is thus proceeding upwards from A to B, a stream of pure water is made to flow along in the opposite direction from B to A, running over the top of each partition in a thin sheet. By this contrivance, the goods which enter at A, having much loose color upon their surface, impregnate the water strongly, but as they advance they continually get cleaner by the immersion, and pressure of the successive rollers, being exposed to purer water, till at last they reach the limpid stream, and are discharged at B perfectly bright. The rinsing operation may be modified by varying the quantity of water admitted, the speed with which the pieces are drawn through the cells, or the pressure upon the series of top rollers.

941



ROCKETS. M. de Montgery, captain of a frigate in the French service, has written a *Traité sur les Fusées de Guerre*, in which he discusses the merits of the Congreve rockets, and describes methods of imitating them. As the subject of military projectiles is foreign to this Dictionary, I refer my readers to the above work, which is commended by the editor of the *Dictionnaire Technologique*.

ROLLING-MILL. See IRON, MINT, and PLATED MANUFACTURE.

ROPE-MAKING. The fibres of hemp which compose a rope, seldom exceed in length three feet and a half, at an average. They must, therefore, be twined together so as to unite them into one; and this union is effected by the mutual circumtorsion of the two fibres. If the compression thereby produced be too great, the strength of the fibres at the points where they join will be diminished; so that it becomes a matter of great consequence to give them only such a degree of twist as is essential to their union.

The first part of the process of rope-making by hand, is that of spinning the yarns or threads, which is done in a manner analogous to that of ordinary spinning. The spinner carries a bundle of dressed hemp round his waist; the two ends of the bundle being assembled in front. Having drawn out a proper number of fibres with his hand, he twists them with his fingers, and fixing this twisted part to the hook of a whirl, which is driven by a wheel put in motion by an assistant, he walks backwards down the rope-walk, the twisted part always serving to draw out more fibres from the bundle round his waist, as in the flax-spinning wheel. The spinner takes care that these fibres are equably supplied, and that they always enter the twisted parts by their ends, and never by their middle. As soon as he has reached the termination of the walk, a second spinner takes the yarn off the whirl, and gives it to another person to put upon a reel, while he himself attaches his own hemp to the whirl hook, and proceeds down the walk. When the person at the reel begins to turn, the first spinner, who has completed his yarn, holds it firmly at the end, and advances slowly up the walk, while the reel is turning, keeping it equally tight all the way, till he reaches the reel, where he waits till the second spinner takes his yarn off the whirl hook, and joins it to the end of that of the first spinner, in order that it may follow it on the reel.

The next part of the process previous to tarring, is that of warping the yarns, or stretching them all to one length, which is about 200 fathoms in full-length rope-grounds, and also in putting a slight turn or twist into them.

The third process in rope-making, is the tarring of the yarn. Sometimes the yarns are made to wind off one reel, and, having passed through a vessel of hot tar, are wound upon another, the superfluous tar being removed by causing the yarn to pass through a hole surrounded with spongy oakum; but the ordinary method is to tar it in skeins or hanks, which are drawn by a capstan with a uniform motion through the tar-kettle. In this process, great care must be taken that the tar is boiling neither too fast nor too slow. Yarn for cables requires more tar than for hawser-laid ropes; and for standing and running rigging, it requires to be merely well covered. Tarred cordage has been found to be weaker than what is untarred, when it is new; but the tarred rope is not so easily injured by immersion in water.

The last part of the process of rope-making, is to lay the cordage. For this purpose two or more yarns are attached at one end to a hook. The hook is then turned the contrary way from the twist of the individual yarn, and thus forms what is called a strand. Three strands, sometimes four, besides a central one, are then stretched at length, and attached at one end to three contiguous but separate hooks, but at the other end to a single hook; and the process of combining them together, which is effected by turning the single hook in a direction contrary to that of the other three, consists in so regulating the progress of the twists of the strands round their common axis, that the three strands receive separately at their opposite ends just as much twist as is taken out of them by their twisting the contrary way, in the process of combination.

Large ropes are distinguished into two main classes, the *cable-laid* and *hawser-laid*. The former are composed of nine strands, namely, three great strands, each of these consisting of three smaller secondary strands, which are individually formed with an equal number of primitive yarns. A cable-laid rope eight inches in circumference, is made up of 333 yarns or threads, equally divided among the nine secondary strands. A *hawser-laid* rope consists of only three strands, each composed of a number of primitive yarns, proportioned to the size of the rope; for example, if it be eight inches in circumference, it may have 414 yarns, equally divided among three strands. Thirty fathoms of yarn are reckoned equivalent in length to eighteen fathoms of rope cable-laid, and to twenty fathoms hawser-laid. Ropes of from one inch to two inches and a half in circumference are usually hawser-laid; of from three to ten inches, are either hawser or cable-laid; but when more than ten inches, they are always cable-laid.

Every hand-spinner in the dock-yard is required to spin, out of the best hemp, six threads, each 160 fathoms long, for a quarter of a day's work. A hawl of yarn, in the warping process, contains 336 threads.

The following are Captain Huddart's improved principles of the rope manufacture:—

1. To keep the yarns separate from each other, and to draw them from bobbins revolving upon skewers, so as to maintain the twist while the strand or primary cord is forming.
2. To pass them through a register, which divides them by circular shells of holes; the number in each concave shell being conformable to the distance from the centre of the strand, and the angle which the yarns make with a line parallel to it, and which gives them a proper position to enter.
3. To employ a tube for compressing the strand, and preserving the cylindrical figure of its surface.
4. To use a gauge for determining the angle which the yarns in the outside shell make with a line parallel to the centre of the strand, when registering; because according to the angle made by the yarns in this shell, the relative lengths of all the yarns in the strand will be determined.
5. To harden up the strand, and thereby increase the angle in the outside shell; which compensates for the stretching of the yarns, and the compression of the strands.

A great many patents have been obtained, and worked with various degrees of success, for making ropes. Messrs. Cartwright, Fothergill, Curr, Chapman, Balfour, and Huddart, have been the most conspicuous inventors in this country; but the limits of this work preclude us doing justice to their respective merits.

All the improvements in the manufacture of cordage at present in use, either in her Majesty's yards or in private rope-grounds, owe their superiority over the old method of making cordage to Captain Huddart's invention of the register plate and tube.

Mr. Balfour took out a patent for the manufacture of cordage about a month before Captain Huddart; but the formation of his strand was to be accomplished by what he called a top minor (in the form of a common top, with pins to divide the yarns), which upon trial could not make cordage so good as by the common mode. On seeing Captain Huddart's specification, Mr. Balfour, five years after, procured another patent, in which he included a plate and tube, but which was not sufficiently correct, and experience in the navy proved the insufficiency of the cordage. Captain Huddart's plate and tube were then adopted in the king's yards, and he gave his assistance for the purpose.

Captain Huddart then invented and took a patent for a machine, which by registering the strand at a short length from the tube, and winding it up as made, preserved a uniformity of twist, or angle of formation, from end to end of the rope, which cannot be accomplished by the method of forming the strands down the ground, where the twist is communicated from one end to the other of an elastic body upwards of 300 yards in length. This registering-machine was constructed with such correctness, that when some were afterwards required, no alteration could be made with advantage by the most skilful and scientific mechanic of that day, Mr. Rennie. Thus the cold register was carried to the greatest perfection.

A number of yarns cannot be put together in a cold state, without considerable vacancies, into which water may gain admission; Captain Huddart, therefore, formed the yarns into a strand immediately as they came from the tar-kettle, which he was enabled to do by his registering-machine, and the result was most satisfactory. This combination of yarns was found by experiment to be 14 per cent. stronger than the cold register; it constituted a body of hemp and tar impervious to water, and had great advantage over any other cordage, particularly for shrouds, as after they were settled on the mast-head, and properly set up, they had scarcely any tendency to stretch, effectually secured the mast, and enabled the ship to carry the greatest press of sail.

In order more effectually to obtain correctness in the formation of cables and large cordage, Captain Huddart constructed a laying-machine, which has carried his inventions in rope-making to the greatest perfection, and which, founded on true mathematical principles, and the most laborious calculations, is one of the noblest monuments of mechanical ability since the improvement of the steam-engine by Mr. Watt. By this machine, the strands receive that degree of twist only which is necessary, and are laid at any angle with the greatest regularity; the pressure is regulated to give the required elasticity, and all parts of the rope are made to bear equally. In no one instance has a rope or cable thus formed been found defective in the lay, or stiff, or difficult to coil.

Such a revolution in the manufacture of cordage could not be accomplished without great expense, as the works at Limehouse fully testify; and considerable opposition necessarily arose. Captain Huddart's first invention was, however, generally adopted, as soon as the patent expired; and experience has established the great importance of his subsequent improvements.

His cordage has been supplied in large quantities to her Majesty's navy, and has received the most satisfactory reports.

The following description of one of the best modern machines for making ropes on Captain Huddart's plan, will gratify the intelligent reader.

Fig. 942 exhibits a side elevation of the tackle-board and bobbin-frame at the head of the ropery, and also of the carriage or rope-machine in the act of hauling out and twisting the strands.

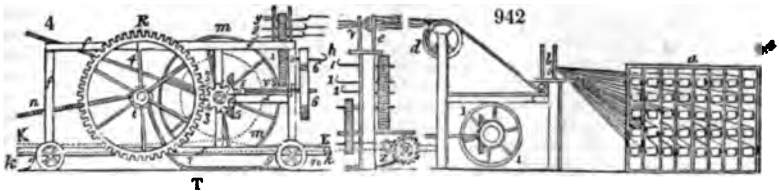

942

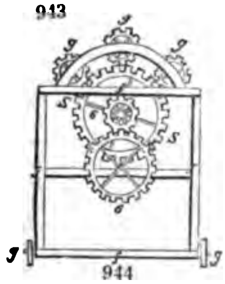
Fig. 943 is a front elevation of the carriage.

Fig. 944 is a yarn-guide, or board, or plate, with perforated holes for the yarns to pass through before entering the nipper.

Figs. 945 and 946 are side and front views of the nipper for pressing the rope-yarns.

a is the frame for containing the yarn bobbins. The yarns are brought from the frame, and pass through a yarn-guide at *b*. *c* is a small roller, under which the rope-yarns pass; they are then brought over the reel *d*, and through another yarn-guide *e*, after which they enter the nippers at *v*, and are drawn out and formed into strands by the carriage. The roller and reel may be made to traverse up and down, so as to regulate the motion of the yarns.

943



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945

The carriage runs on a railway. *f*, *f*, is the frame of the carriage; *g*, *g*, are the small wheels on which it is supported; *k*, *k*, is an endless rope, reaching from the head to the bottom of the railway, and is driven by a steam-engine; *m*, *m*, is a wheel with gubs at the back of it, over which the endless rope passes, and gives motion to the machinery of the carriage. *n*, is the ground rope for taking out the carriage, as will be afterwards described. On the shaft of *m*, *m*, are two bevel wheels 3, 3, with a shifting catch between them; these bevel wheels are loose upon the shaft, but when the catch is put into either of them, this last then keeps motion with the shaft, while the other runs loose. One of these wheels serves to communicate the twist to the strand in drawing out; the other gives the opposite or after turn to the rope in closing. 4, 4, is a lever for shifting the catch accordingly. 5, is a third bevel wheel, which receives its motion from either of the other two, and communicates the same to the two spur wheels 6, 6, by means of the shaft *x*. These can be shifted at pleasure; so that by applying wheels of a greater or less number of teeth above and beneath, the twist given to the strands can be increased or diminished accordingly. The upper of these two communicates motion, by means of the shaft *o*, to another spur wheel 8, which working in the three pinions above, 9, 9, gives the twist to the strand hooks.

The carriage is drawn out in the following manner. On the end of the shaft of *m*, *m*, is the pinion 3, which, working in the large wheel R, gives motion to the ground-rope shaft upon its axis. In the centre of this shaft is a curved pulley or drum *t*, round which the ground-rope takes one turn. This rope is fixed at the head and foot of the ropery; so that when the machinery of the carriage is set a-going by the endless rope *k*, *k*, and gives motion to the ground-rope shaft, as above described, the carriage will necessarily move along the railway; and the speed may be regulated either by the diameter of the circle formed by the gubs on the wheel *m*, *m*, or by the number of teeth in the pinion 3. At T, is a small roller, merely for preventing the ground-rope from coming up among the machinery. At the head of the railway, and under the tackle-board, is a wheel and pinion z, with a crank for tightening the ground-rope. The fixed machinery at the head, for hardening or tempering the strands, is similar to that on the carriage, with the exception of the ground-rope gear, which is unnecessary. The motion is communicated by another endless rope (or short band, as it is called, to distinguish it from the other), which passes over gubs at the back of the wheel 1, 1.

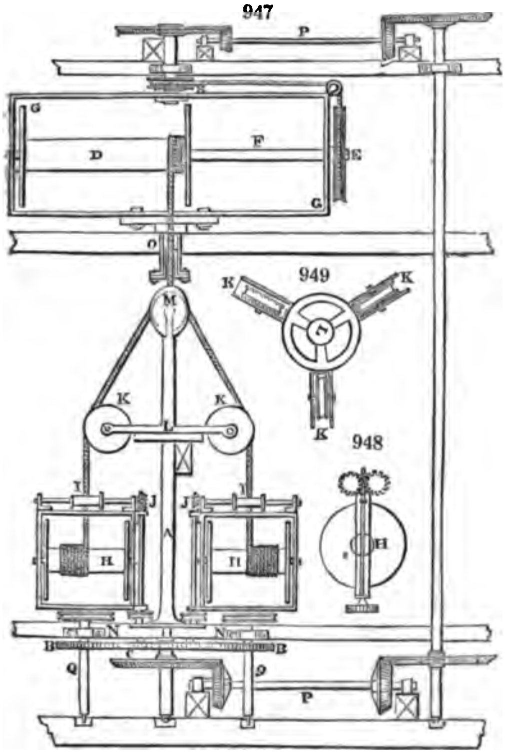
When the strands are drawn out by the carriage to the requisite length, the spur wheels 3, R, are put out of gear. The strands are cut at the tackle-board, and fixed to the hooks 1, 1, 1; after which they are hardened or tempered, being twisted at both ends. When this operation is finished, three strands are united on the large hook *h*, the top put in, and the rope finished in the usual way.

In preparing the hemp for spinning and ordinary thread or rope yarn, it is only heckled over a large keg or clearer, until the fibres are straightened and separated, so as to run freely in the spinning. In this case, the hemp is not stripped of the tow, or cropped, unless it is designed to spin beneath the usual grist, which is about 20 yarns for the strand of a three-inch strap-laid rope. The spinning is still performed by hand, being found not only to be more economical, but also to make a smoother thread, than has yet been effected by machinery. Various ways have been tried for preparing the yarns for tarring. That which seems now to be most generally in use, is, to warp the yarns upon the stretch as they are spun. This is accomplished by having a wheel at the foot, as well as the head of the walk, so that the men are able to spin both up and down, and also to splice their threads at both ends. By this means, they are formed into a haul, resembling the warp of a common web, and a little turn is hove into the haul, to preserve it from getting foul in the tarring. The advantages of warping from the spinners, as above, instead of winding on winches, as formerly, are, 1st, the saving of this last operation altogether; 2dly, the complete check which the foreman has of the quantity of yarn spun in the day; 3dly, that the quality of the work can be subjected to the minutest inspection at any time. In tarring the yarn, it is found favorable to the fairness of the strip, to allow it to pass around or under a reel or roller in the bottom of the kettle while boiling, instead of coiling the yarn in by hand. The tar is then pressed from the yarn, by means of a sliding nipper, with a lever over the upper part, and to the end of which the necessary weight is suspended. The usual proportion of tar in ordinary ropes, is something less than a fifth. In large strap-laid ropes, which are necessarily subjected to a greater press in the laying of them, the quantity of tar can scarcely exceed a sixth, without injuring the appearance of the rope when laid.

For a long period, the manner of laying the yarns into ropes, was by stretching the haul on the rope-ground, parting the number of yarns required for each strand, and twisting the strands at both ends, by means of hand-hooks, or cranks. It will be obvious that this method, especially in ropes of any considerable size, is attended with serious disadvantages. The strand must always be very uneven; but the principal disadvantage, and that which gave rise to the many attempts at improvement, was, that the yarns being all of the same length before being twisted, it followed, when the rope was finished, that while those which occupied the circumference of the strand were perfectly tight, the centre yarns, on the other hand, as they were now greatly slackened by the operation of hardening or twisting the strands, would actually bear little or no part of the strain when the rope was stretched, until the former gave way. The method displayed in the preceding figures and description, is among the latest and most improved. Every yarn is given out from the bobbin frame as it is required in twisting the rope; and the twist communicated in the out-going of the carriage, can be increased or diminished at pleasure. In order to obtain a smooth and well-filled strand, it is necessary also, in passing the yarns through the upper board, to proportion the number of centre to that of outside yarns. In ordinary sized ropes, the strand seems to have the fairest appearance, when the outside yarns form from $\frac{2}{3}$ds to $\frac{3}{4}$ths of the whole quantity, in the portion of twist given by the carriage in drawing out and forming the strands.

In laying cables, torsion must be given both behind and before the laying top. *Figs.* 947, 948, 949 represent the powerful patent apparatus employed for this purpose. A, is a strong upright iron pillar, supported upon the great horizontal beam N, N, and bearing at its upper end the three-grooved laying top M. H, H, are two of the three great bobbins or reels round which the three secondary strands or small hawsers are wound. These are drawn up by the rotation of the three feeding rollers I, I, I, thence proceed over the three guide pulleys K, K, K, towards the laying top M, and finally pass through the tube O, to be wound upon the cable-reel D. The frames of the three bobbins H, H, H, do not revolve about the fast pillar A, as a common axis; but each bobbin revolves round its own shaft Q, which is steadied by a bracing collet at N, and a conical step at its bottom. The three bobbins are placed at an angle of 120 degrees apart, and each receives a rotatory motion upon its axis from the toothed spur wheel B, which is driven by the common central spur wheel C. Thus each of the three secondary cords has a proper degree of twist put into it in one direction, while the cable is laid, by getting a suitable degree of twist in an opposite direction, from the revolution of the frame or cage G, G, round two pivots, the one under the pulley E, and the other over O.

947



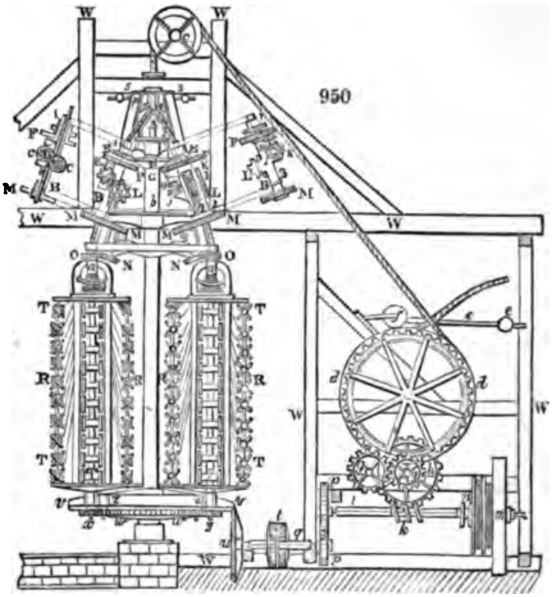
The reel D has thus, like the bobbins H, H, two movements; that in common with its frame, and that upon its axis, produced by the action of the endless band round the pulley E, upon one of its ends, and the pulley E′ above its centre of rotation. The pulley E is driven by the bevel mill-gearing P, P, P, as also the under spur-wheel C. L, in *fig.* 949, is the place of the ring L, *fig.* 947, which bears the three guide pulleys K, K, K. *Fig.* 948 is an end view of the bobbin H, to show the worm or endless screw J, of *fig.* 949, working into the two snail-toothed wheels, upon the ends of the two feed-rollers I, I, which serve to turn them. The upright shafts of J, J, receive their motion from pulleys and cords near their bottom. Instead of these pulleys, and the others E, E′, bevel-wheel gearing has been substituted with advantage, not being liable to slip, like the pulley-band mechanism. The axis of the great reel is made twice the length of the bobbin D, in order to allow of the latter moving from right to left, and back again alternately, in winding on the cable with uniformity as it is laid. The traverse mechanism of this part is, for the sake of perspicuity, suppressed in the figure.

Mr. William Norvell, of Newcastle, obtained a patent in May, 1833, for an improvement adapted to the ordinary machines employed for twisting hempen yarns into strands, affording, it is said, a simpler and more eligible mode of accomplishing that object, and also of laying the strands together, than has been hitherto effected by machinery. The yarns spun from the fibres of hemp are wound upon bobbins, and these bobbins are mounted upon axles, and hung in the frame of the machine, as shown in the elevation, *fig.* 950, from which bobbins the several ends of yarn are passed upwards through slanting tubes; by the rotation of which tubes, and of the carriages in which the bobbins are suspended, the yarns become twisted into strands, and also the strands are laid so as to form ropes.

His improvements consist, first, in the application of three or more tubes, two of which are shown in *fig.* 950, placed in inclined positions, so as to receive the strands immediately above the press-block *a*, *a*, and nearly in a line with A, the point of closing or laying the rope. B′, and B³, are opposite side views; B², an edge view; and B, a side section of the same. He does not claim any exclusive right of patent for the tubes themselves, but only for their form and angular position.

Secondly, in attaching two common flat sheaves, or pulleys, C, C, *fig.* 950, to each of the said tubes, nearly round which each strand is lapped or coiled, to prevent it from slipping, as shown in the section B′. The said sheaves or pulleys are connected by a crown or centre wheel D, loose upon *b*, *b*, the main or upright axle; E, E, is a smaller wheel upon each tube, working into the said crown or centre wheel, and fixed upon the loose box I, on each of the tubes.

F, F, is a toothed or spur wheel, fixed also upon each of the loose boxes I, and working into a smaller wheel G, upon the axis 2, of each tube; H, is a bevel wheel fixed upon the same axis with G, and working into another bevel wheel *j*, fixed upon the cross axle 3, of each tube; K, is a spur wheel attached to the same axis with *j*, at the opposite end, and working into L, another spur wheel of the same size upon each of the tubes. By wheels thus arranged and connected with the sheaves or pulleys, as above described, a perfectly equal strain or tension is put upon each strand as drawn forward over the pulley C.



Thirdly, the invention consists in the introduction of change wheels M, M, M, M, *fig.* 50, for putting the foreband or proper twist into each strand before the rope is laid; this is effected by small spindles on axles 4, 4, placed parallel with the line of each tube B.

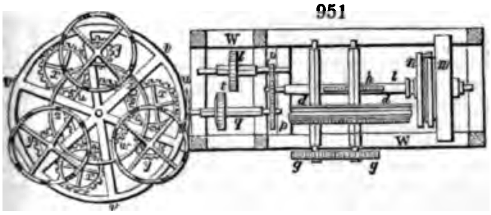
Upon the lower end of each spindle the bevel wheels N, N, are attached, and driven by other bevel wheels o, o, fixed immediately above each press-block *a*, *a*. On the top end of each spindle or axle 4, 4, is attached one of the change wheels, working into the other change wheel fixed upon the bottom end of each of the tubes, whereby the forehard or proper twist in the strands for all sizes of ropes, is at once attained, by simply changing the sizes of those two last described wheels, which can be very readily effected, from the manner in which they are attached to the tubes B, B, and 4, 4.

From the angular position of the tubes towards the centre, the strands are nearly in contact at their upper ends, where the rope is laid, immediately below which the forehard or proper twist is given to the strands.

Fourthly, in the application of a press-block P, of metal, in two parts, placed directly above and close down to where the rope is laid at A, the inside of which is polished, and the under end is bell-mouthed; to prevent the rope from being chafed in entering it, a sufficient grip or pressure is put upon the rope by one or two levers and weights 5, 5, acting upon the press-block, so as to adjust any trifling irregularity in the strand or in the laying; the inside of which being polished, gives smoothness, and by the said levers and weights, a proper tension to the rope, as it is drawn forward through the press-block. By the application of this block, ropes may be made at once properly stretched, rendering them decidedly preferable and extremely advantageous, particularly for shipping, inclined planes, mines, &c.

The preceding description includes the whole of Mr. Norvell's improvements; the remaining parts of the machine, being similar to those now in use, may be briefly described as follows:—A wheel or pulley *c*, is fixed independently of the machine, over which the rope passes to the drawing motion represented at the side; *d*, *d*, is a grooved wheel, round which the rope is passed, and pressed into the groove by means of the lever and weight *e*, *e*, acting upon the binding sheaf *f*, to prevent the rope from slipping. After the rope leaves the said sheave, it is coiled away at pleasure. *g*, *g*, are two change wheels, for varying the speed of the grooved wheel *d*, *d*, to answer the various sizes of ropes; *h*, is a spiral wheel, driven by the screw *k*, fixed upon the axle *l*; *m*, is a band-wheel, which is driven by a belt from the shaft of the engine, or any other communicating power; *n*, *n*, is a friction strap and striking clutch. The axle *q*, is driven by two change wheels *p*, *p*; by changing the sizes of those wheels, the different speeds of the drum R, R, for any sizes of ropes, are at once effected.

951



The additional axle *s*, and wheels *t*, *t*, shown in *fig.* 951, are applied occasionally for reversing the motion of the said drums, and making what is usually termed left-hand ropes; *u*, *figs.* 950, and 951, show a bevelled pinion, driving the main crown wheel *v*, *v*, which wheel carries and gives motion to the drums R, R; *w*, *w*, is a fixed or sun wheel, which gives a reverse motion to the drums, as they revolve round the same, by means of the intervening wheels *x*, *x*, *x*, whereby the reverse or retrograding motion is produced, and which gives to the strands the right twist. The various retrograding motions, or right twists for all sizes and descriptions of ropes, may be obtained by changing the diameters of the pinions *y*, *y*, *y*, on the under ends of the drum spindles; the carriages of the intervening wheels *x*, *x*, *x*, being made to slide round the ring *z*, *z*; W, W, is the framework of the machine and drawing motion; T, T, T, are the bobbins containing the yarns; their number is varied to correspond with the different sizes of the machines.

The machine here described, in elevation and plan, is calculated to make ropes from three to seven and one half inches in circumference, and to an indefinite length.

Messrs. Chapman of Newcastle, to whom the art of rope-making is deeply indebted, having observed that rope-yarn is considerably weakened by passing through the tar-kettle, that tarred cordage loses its strength progressively in cold climates, and so rapidly in hot climates as to be scarcely fit for use in three years, discovered that the deterioration was due to the reaction of the mucilage and acid of the tar. They accordingly proposed the following means of amelioration. 1. Boiling it with water, in order to remove these two soluble constituents. 2. Concentrating the washed tar by heat, till it becomes pitchy, and then restoring the plasticity which it thereby loses, by the addition of tallow, or animal or expressed oils.

In 1807, the same able engineers obtained a patent for a method of making a belt or flat band, of two, three, or more strands of shroud or hawser-laid rope, placed side by side, so as to form a band of any desired breadth, which may be used for hoisting the kibbles and corves in mine-shafts, without any risk of its losing twist by rotation. The ropes should be laid with the twist of the one strand directed to the right hand, that of the other to the left, and that of the yarns the opposite way to the strands, whereby perfect flatness is secured to the band. This parallel assemblage of strands has been found also to be stronger than when they are all twisted into one cylinder. The patentees at the same time contrived a mechanism for piercing the strands transversely, in order to brace them firmly together with twine. Flat ropes are usually formed of hawsers with three strands, softly laid, each containing 33 yarns, which with four ropes, compose a cordage four and a half inches broad, and an inch and a quarter thick, being the ordinary dimensions of the grooves in the whim-pulleys round which they pass.

Relative Strength of Cordage, shroud laid.

Size.	Warm Register.				Cold Register.				Common Staple.			
	Tons	Cwts	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts	Qrs.	Lbs.
3 inches bore -	3	17	—	16	3	5	3	16	2	9	1	24
3½ —	5	5	—	—	4	9	2	21	3	6	1	27
4 —	6	17	—	16	5	17	—	4	4	5	3	1
4½ —	8	13	2	8	7	5	3	1	5	1	2	6
5 —	10	14	1	4	9	3	—	4	6	9	2	8
5½ —	12	19	2	4	11	1	1	25	7	12	—	22
6 —	14	15	2	24	13	3	2	8	8	17	1	20
6½ —	18	2	—	10	15	9	1	9	9	16	3	14
7 —	21	—	—	—	17	18	3	8	11	4	1	21
7½ —	21	2	—	16	20	11	3	9	12	8	3	6
8 —	27	8	1	26	23	8	2	8	13	2	3	12

The above statement is the result of several hundred experiments.

ROSIN, or **COLOPHANY** (*Galipot*, Fr.; *Fichtenharz*, Germ.), is the rosin left after distilling off the volatile oil from the different species of turpentine. Yellow rosin contains some water, which black rosin does not. See Turpentine.

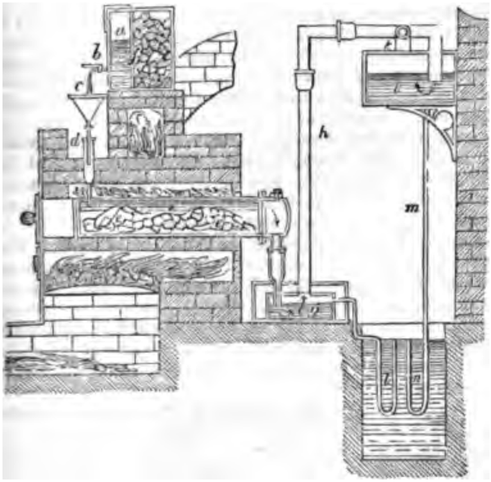
ROSIN GAS. *Fig.* 952 exhibits the retort and its appendages, as erected by Messrs. Taylor and Martineau, under the direction of the patentee, Professor Daniel, F. R. S.

I have introduced this manufacturing project, not as a pattern to imitate, but as an example to deter; as affording a very instructive lesson of the danger of rushing headlong into most extensive enterprises, without fully verifying, upon a moderate scale, the probability of their ultimate success. The capital, labor, and time annually wasted upon visionary schemes of this sort, got up by chamber chemists, are incalculably great. No more essential service could be rendered to the cause of productive industry, than to unmask the thousand and one chimerical inventions which disgrace our lists of patents during the last thirty years. These remarks have been suggested by the circumstance, that 50,000*l.* were squandered upon the rosin-gas concern; a fact communicated to me by an eminent capitalist, who was induced by fallacious statements to embark largely in the speculation. Had 100*l.* been employed beforehand, by a dispassionate practical man, in making judicious trials, and in calculating the chances of eventual profit and loss, it would have been demonstrated, as clearly as noonday, that rosin could never compete with pitcoal in the production of gas-light. Whatever ingenuity was expended in getting up the following apparatus, may be regarded as an additional *ignis fatuus* to mislead the public, and divert their thoughts from the abyss that lay before them. The main preliminary to be settled, in all new undertakings, is the soundness of the principle. By neglecting this point, projectors perpetually realize the expiatory fable of the Danaids.

The retort *c, c*, *fig.* 952, is seen charged with coke, which is in the first instance raised to a bright red heat, by means of the furnace beneath. The common brown rosin of commerce, which is deposited in the tank *a*, is to be mixed with the essential oil (condensed from the rosin vapors in a preceding operation) in the proportion of one hundred pounds of the former to ten gallons of the latter. The influence of the flame and heated air beneath serves to preserve this in a fluid state, and by a damper passing across the aperture in the chimney the temperature of the fluid may be exactly regulated. A wire-gauze screen at *f*, reaches to the bottom of the tank, and prevents the solid rosin, or any impurity with which it may be mixed, from choking the stopcock.

The melted rosin having passed by the stopcock *b*, funnel *c*, and syphon *d*, into the retort, falls on the coke, and in its passage through the ignited mass, becomes decomposed. On arriving at the other end of the retort, a large portion of the oil of turpentine, in the form of condensable vapor, is separated by the refrigerator *g*; this is supplied with water from a cistern above, and the non-condensable vapor or gas passes up the tube *h*, and dips beneath the surface of the fluid in the vessel *i*. This completes the condensation; and the gas proceeds in a perfectly pure state, by the pipe *k*, to the gasometer, or rather to the floating reservoir, for use.

962



The essential oil, when it leaves the refrigerator, is conveyed, by the syphon *l*, to a cistern beneath. The necessity for employing a syphon will be apparent, when it is borne in mind that the tube prevents the escape of the gas, which would otherwise pass away from the box with the essential oil. Another pipe and syphon *m*, *n*, serve to convey the condensed essential oil from the top cistern.

ROTTEN-STONE. See Tripoli.

ROUGE. (*Fard*, Fr.) The only cosmetic which can be applied without injury to brighten a lady's complexion, is that prepared, by the following process, from safflower, (*Carthamus tinctorius.*) The flowers, after being washed with pure water till it comes off colorless, are dried, pulverized, and digested with a weak solution of crystals of soda, which assumes thereby a yellow color. Into this liquor a quantity of finely carded white cotton wool is plunged, and then so much lemon juice or pure vinegar is added as to supersaturate the soda. The coloring matter is disengaged, and falls down in an impalpable powder upon the cotton filaments. The cotton, after being washed in cold water, to remove some yellow coloring particles, is to be treated with a fresh solution of carbonate of soda, which takes up the red coloring matter in a state of purity. Before precipitating this pigment a second time by the acid of lemons, some soft powdered talc should be laid in the bottom of the vessel, for the purpose of absorbing the fine rouge, in proportion as it is separated from the carbonate of soda, which now holds it dissolved. The colored mixture must be finally triturated with a few drops of olive oil, in order to make it smooth and marrowy. Upon the fineness of the talc, and the proportion of the safflower precipitate which it contains, depend the beauty and value of the cosmetic. The rouge of the above second precipitation is received sometimes upon bits of fine-twisted woollen stuff, called *crepons*, which ladies rub upon their cheeks.

RUBY. See Lapidary.

RUM, is a variety of ardent spirits, distilled in the West Indies, from the fermented skimmings of the sugar teaches, mixed with molasses, and diluted with water to the proper degree. A sugar plantation in Jamaica or Antigua, which makes 200 hogsheads of sugar of about 16 cwts. each, requires, for the manufacture of its rum, two copper stills; one of 1000 gallons for the wash, and one of 600 gallons for the low wines, with corresponding worm refrigeratories. It also requires two cisterns, one of 3000 gallons for the lees or spent wash of former distillations, called dunder (*Quasi redundar*, Span.), another for the skimmings of the clarifiers and teaches of the sugarhouse; along with twelve, or more, fermenting cisterns or tuns.

Lees that have been used more than three or four times, are not considered to be equally fit for exciting fermentation, when mixed with the sweets, as fresher lees. The wort is made, in Jamaica, by adding to 1000 gallons of dunder, 120 gallons of molasses, 720 gallons of skimmings (= 120 of molasses in sweetness), and 160 gallons of water; so that there may be in the liquid nearly 12 per cent. of solid saccharum. Another proportion, often used, is 100 gallons of molasses, 200 gallons of lees, 300 gallons of skimmings, and 400 of water; the mixture containing, therefore, 15 per cent. of sweets. These two formulæ prescribe so much spent wash, according to my opinion, as would be apt to communicate an unpleasant flavor to the spirits. Both the fermenting and flavoring principles reside chiefly in the fresh cane juice, and in the skimmings of the clarifier; because, after the sirup has been boiled, they are in a great measure dissipated. I have made many experiments upon fermentation and distillation from West India molasses, and always found the spirits to be perfectly exempt from any rum flavor.

The fermentation goes on most uniformly and kindly in very large masses, and requires from 9 to 15 days to complete; the difference of time depending upon the strength of the wort, the condition of its fermentable stuff, and the state of the weather. The progress of the attenuation of the wash should be examined from day to day with a hydrometer, as I have described in the article DISTILLATION. When it has reached nearly to its *maximum*, the wash should be as soon as possible transferred by pumps into the still, and worked off by a properly regulated heat; for if allowed to stand over, it will deteriorate y acetification. Dr. Higgins's plan, of suspending a basket full of limestone in the wash tuns, to counteract the acidity, has not, I believe, been found to be of much use. It would be better to cover up the wash from the contact of atmospheric air, and to add perhaps a very little *sulphite* of lime to it, both of which means would tend to arrest the acetous fermentation. But one of the best precautions against the wash becoming sour, is to preserve the utmost cleanliness among all the vessels in the distillery. They should be scalded at the end of every round with boiling water and quicklime.

About 115 gallons of proof rum are usually obtained from 1200 gallons of wash. The proportion which the product of rum bears to that of sugar, in very rich moist plantations, is rated, by Edwards, at 82 gallons of the former to 16 cwt. of the latter; but the more usual ratio is 200 gallons of rum to 3 hogsheads of sugar. But this proportion will necessarily vary with the value of rum and molasses in the market, since whichever fetches the most remunerating price, will be brought forward in the greatest quantity. In one considerable estate in the island of Grenada, 92 gallons of rum were made for every hogshead (16 cwts.) of sugar. See STILL.

	Rum imported, in			Retained for Home Consumption.—Duty 9s per Imp. Gallon.		
	1835.	1836.	1837.	1835.	1836.	1837.
Galls.	5,540,170;	4,993,942;	4,612,416.	3,416,966;	3,325,068;	3,184,599.

RUST, is the orange-yellow coat of peroxyde which forms upon the surface of iron exposed to moist air. Oil-paint, varnish, plumbago, or a film of caoutchouc, may be employed, according to circumstances, to prevent the rusting of iron utensils.

RYE, consists, according to the analysis of Einhof, of 24·2 of husk, 65·6 of flour, and 10·2 of water, in 100 parts. This chemist found in 100 parts of the flour, 61·07 of starch, 9·48 of gluten, 3·28 of vegetable albumen, 3·28 of uncrystallizable sugar, 11·09 of gum, 6·38 of vegetable fibre, and the loss was 5·62, including a vegetable acid not yet investigated. Some phosphate of lime and magnesia are also present. See GIN.

S

SAFETY LAMP. I have reserved for this place an account of the patented improvement made upon Davy's lamp, by Messrs. Upton and Roberts; the latter of whom, having worked in coal mines from a boy, and having observed, that in peculiar circumstances the Davy was insecure, was led to contrive certain modifications of it, for which he received, some years ago, a reward from the Society of Arts. It appears from undoubted experiments, that if a jet of carbureted hydrogen (coal gas for example) be impelled with very moderate force against the side of the Davy, it will first fill the wire cylinder of the burning lamp with flame, and then take fire itself exteriorly. This passage of the flame of explosive gases through the meshes of wire gauze of the fineness prescribed for safety lamps by Sir H. Davy was demonstrated in several trials before the select committee of the House of Commons on accidents in mines, by Mr. Pereira, at the London University.* While the gas is at rest, relatively to Davy's lamp, the explosion has never been known to pass; but "if," says Mr. Pereira, "a lamp be held before a jet of gas until it becomes hot (a red heat is not essential), and then gently moved, the flame will pass, and the experiment may be repeated successively a number of times in the minute." Two layers of wire gauze, though they greatly impede the transmission of light, will still permit that of flame, in the above circumstances. In Upton and Roberts' lamp, there is but one coat of wire gauze, but it is enclosed in a glass cylinder, in such a manner as to admit the air which feeds the flame only under its bottom, first through an annular range of holes, and next through one disc, or several, of wire gauze, fixed a little way below the wick. The explosive air, after passing up through these wire-gauze discs, enters a little brass cupola, and is reflected inwards from the orifice at its top upon the flame, whereby it is completely burned before it reaches the cavity of the surmounting cylinder. By this reverberatory action of the air upon the wick, the intensity of the light is at the same time greatly augmented. Since the feed orifices of the lamp are small in comparison with the capacity of the surmounting cage, the latter does not get filled with flame on being plunged in an explosive gaseous mixture, as happens to the naked cage of Davy. The wire-gauze can never, therefore, become very hot, far less ignited, in the new lamp. There are, in fact, three impediments to the passage of the flame

*On the 30th of July, 1835

: of the lamp; first, the stratum of carbonic acid round the light; secondly, the wire-ıze cylinder; and thirdly, the glass cylinder. The entrance at the bottom may be de secure in any desired degree, by multiplying the layers of wire cloth. The top is tected, moreover, by a brass hood, through which the currents of carbonic acid and rogen gases, continually ascending from the burning wick, oppose certain obstacles to ; transmission of flame downwards. Even should the glass be accidentally broken, the ıp is still a complete Davy.

In the experiments made before the honorable committee at the London University, ·. Pereira showed, first, that when a jet of coal-gas alone, or an explosive mixture of ıl-gas and air, impinged upon the wire-gauze cylinder of one of Davy's lamps with a tain force, the flame generally passed through the meshes, of which there were from) to 1024 in the square inch. When a mixture of four parts of hydrogen and one coal-gas was directed in a jet upon the lighted lamps of Davy, Stevenson, Dillon, ood of Killingworth (called the refrigerating lamp), Robson, and Clanny, the flame ıdily passed; but when thrown upon the lamp of Upton and Roberts, it did not once ıs, causing merely slight detonations within the lamp. When the force of the jet was gmented, it extinguished the light. This lamp was finally subjected to the still severer t of a mixture of four parts of atmospherical air, and one of hydrogen; yet it did not plode it. When exposed to a mixture of two thirds of air, and one of hydrogen, the np was immediately extinguished.

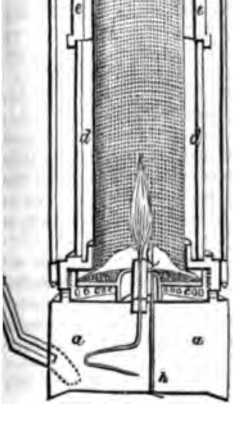
The following, out of many certificates, appears to me decisive in favor of this improvement of Davy's lamp. It comes from an experienced pitman, in a very deep and extene coal mine, which I know to be replete with explosive gas, as I have myself visited it company with its accomplished engineer, John Buddle, Esq.

" I hereby certify that I have this day tried Messrs. Upton and Roberts' new patent ety lamp, in the Jarrow colliery; and I state, as an experienced pitman, having been rty-two years master wasteman in that colliery, that I greatly prefer this new lamp the common Davy lamp. I had it between five and six hours on trial in the pit. I ısider that it gives about three times the light of the Davy lamp, as I could see at least ı yards before me in a straight line; and of its great safety I can have no doubt, as it ıs not fill with flame, as the Davy does. And although I had this extra light, there s much less oil consumed. I consider it a good working lamp."

" Jarrow Colliery, near Newcastle on Tyne, March 31, 1836." (Signed) " ROBERT FAIRLY."

Fig. 953 is a vertical section through the middle of the lamp. *a*, *a*, is the oil-cistern, showing the fold of the wick; it is covered at top with *b*, *b*, several layers of wire gauze; *c*, *c*, is the perforated brass ring, under these layers, for admitting air, which is reverberated upon the burning wick by the cupola c; *d*, *d*, is the cylinder of glass, surrounding the wire-cloth one; *e*, *e*, is the safety brass hood, which screws down in the frame, so as to cover in the top of the glass chimney; *f*, is the arched wire for suspending the lamp to the girdle of the miner; *g*, is the bent tube for supplying oil to the cistern; and *h* is the safety-trimmer, shown more distinctly in the figure illustrative of the LAMP of DAVY.

953



Between the glass and the cage there should be a space of about one tenth of an inch, forming an annular chimney for the free ventilation of the flame; and between the under edge of the hood *e*, and the upper rim of the glass, there should likewise be an interval, as also vent-holes in the top of the hood, for the free escape of the smoke. The orifice of the little tube *g*, should be rather lower than the ring of holes *c*, otherwise the oil, when incautiously poured into it, might overflow them, and prevent the lamp from burning. *The figure is drawn somewhat in perspective.*

As the naked cage of Davy often gets redhot with flame; as it is sometimes used for hours by miners in this most hazardous state; as this lamp gives so little light as to tempt rash men to remove its safety-cage;* as "it is upon record, that taking the average of ten years previous to the introduction of Sir H. Davy's safety lamp, and allowing one clear year for its introduction, and of ten years after it was properly introduced, there had been double the number of accidents, and at least double the number of deaths, of

At Rowni Harraton June 20, 1817, thirty-eight lives were lost by the wilfulness of one man what took place in the ten years previous to its introduction;[*] as his lamp in explosive air-courses needs to be carried close upon the bosom, or under the coat of the miner; as it was declared by its illustrious inventor to be dangerous when exposed to such currents of explosive gas; and as the above described modification of it is free from all these defects and dangers, I humbly apprehend that no conscientious proprietor or viewer of coal-mines will delay to substitute the lamp of Upton and Roberts for the naked Davy, for otherwise he will certainly stand in a very painful predicament before a coroner's inquest, at the next mortal casualty from explosion.

The patentees have, I am told, been put to so much trouble and expense in trying to introduce this life-protector into our coal-mines, that they have in a great measure abandoned the business. Messrs. Smith of Birmingham have meanwhile undertaken to make the lamps.

SAFFLOWER. This dye-stuff has been fully described under CARTHAMUS and ROUGE.

SAFFRON (*Saffran*, Fr. and Germ.) is a filamentous cake, composed of the stigmata of the flowers of the *Crocus sativus*. It contains a yellow matter called *polychroïte*, because a small quantity of it is capable of coloring a great body of water. This is obtained by evaporating the watery infusion of saffron to the consistence of an extract, digesting the extract with alcohol, and concentrating the alcoholic solution. The polychroite remains in the form of a brilliant mass, of a reddish-yellow color, transparent, and of the consistence of honey. It has the agreeable smell, with the bitter pungent taste, of saffron. It is very soluble in water; and if it be stove-dried, it deliquesces speedily in the air. According to M. Henry *père*, polychroïte consists of eighty parts of coloring matter, combined with 20 parts of a volatile oil, which cannot be separated by distillation till the coloring matter has been combined with an alkali. By mixing one part of shred saffron with eight parts of saturated brine, and one half part of caustic ley, and distilling the mixture, the oil comes over into the receiver, and leaves the coloring matter in the retort, which may be precipitated from the alkaline solution by an acid. The pure coloring matter, when dried, is of a scarlet hue, and then readily dissolves in alcohol, as also in the fat and volatile oils, but sparingly in water. Light blanches the reddish-yellow of saffron, even when it is contained in a full vial well corked. Polychroïte, when combined with fat oil, and subjected to dry distillation, affords ammonia, which shows that azote is one of its constituents. Sulphuric acid colors the solution of polychroïte indigo blue, with a lilach cast; nitric acid turns it green, of various shades, according to the state of dilution. Protochloride (muriate) of tin produces a reddish precipitate.

Saffron is employed as a seasoning in French cookery. It is also used to tinge confectionary articles, liqueurs, and varnishes; but rarely as a pigment.

SAGO (*Sagou*, Fr. and Germ.) is a species of starch, extracted from the pith of the sago palm, a tree which grows to the height of 30 feet in the Moluccas and the Philippines. The tree is cut down, cleft lengthwise, and deprived of its pith, which being washed with water upon a sieve, the starchy matter comes out, and soon forms a deposite. This is dried to the consistence of dough, pressed through a metal sieve to corn it (which is called *pearling*), and then dried over a fire with agitation in a shallow copper pan. Sago is sometimes imported in the pulverulent state, in which it can be distinguished from arrow-root only by microscopic examination of its particles. These are uniform and spherical, not unequal and ovoid, like those of arrow-root.

SAL AMMONIAC. The manufacture of this salt may be traced to the remotest era. Its name is derived from Ammonia, or the temple of Jupiter Ammon, in Egypt, near to which the salt was originally made. Sal ammoniac exists ready formed in several animal products. The dung and urine of camels contain a sufficient quantity to have rendered its extraction from them a profitable Egyptian art in former times, in order to supply Europe with the article. In that part of Africa, fuel being very scarce, recourse is had to the dung of these animals, which is dried for that purpose, by plastering it upon the walls. When this is afterwards burned in a peculiar kind of furnace, it exhales a thick smoke, replete with sal ammoniac in vapor; the soot of course contains a portion of that salt, condensed along with other products of combustion. In every part of Egypt, but especially in the Delta, peasants are seen driving asses loaded with bags of that soot, on their way to the sal ammoniac works.

Here it is extracted in the following manner. Glass globes coated with loam are filled with the soot pressed down by wooden rammers, a space of only two or three inches being left vacant, near their mouths. These globes are set in round orifices formed in the ridge of a long vault, or large horizontal furnace flue. Heat is gradually applied by a fire of dry camels' dung, and it is eventually increased till the globes become obscurely

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unscrewing it, though he was well forewarned of the danger. He said, "he could not see with that thing," meaning the Davy.—*Buddle, in Report of House of Commons*, p. 215.

[*] Dr. Reid Clanny, in Report on Accidents in Mines, p. 32. I observe that in Sykes' *Local Records* of the counties of Durham and Northumberland, corrected by J. Buddle, Esq., there are 540 deaths by explosions, between June, 1817, and June, 1835. What a mass of misery to the families of the sufferers!

ted. As the muriate of ammonia is volatile at a temperature much below ignition, it rises out of the soot in vapor, and gets condensed into a cake upon the inner surface of the top of the globe. A considerable portion, however, escapes into the air; and another portion concretes in the mouth, which must be cleared from time to time by an iron rod. Towards the end, the obstruction becomes very troublesome, and must be most carefully attended to and obviated, otherwise the globes would explode by the uncondensed vapors. In all cases, when the subliming process approaches to a conclusion, the globes crack or split; and when they come to be removed, after the heat has subsided, they usually fall to pieces. The upper portion of the mass is separated, because to it the white salt adheres; and on detaching the pieces of glass with a hatchet, it is ready for the market. At the bottom of each balloon a nucleus of salt remains, surrounded with fixed pulverulent matter. This is reserved, and after being bruised, is put in along with the charge of soot in a fresh operation.

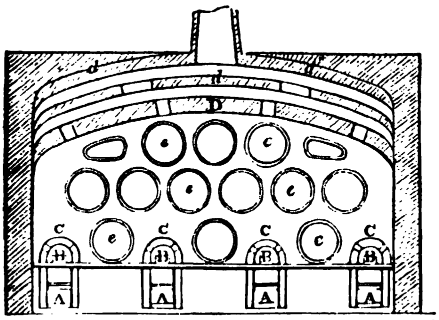
The sal ammoniac obtained by this process is dull, spongy, and of a grayish hue; but nothing better was for a long period known in commerce. Forty years ago, it fetched 2*s*. 6*d*. a pound; now, perfectly pure sal ammoniac may be had at one fifth part of that price.

Various animal offals develop during their spontaneous putrefactive fermentation, or their decomposition by heat, a large quantity of free or carbonated ammonia, among their volatile products. Upon this principle many sal ammoniac works have been established. In the destructive distillation of pitcoal, there is a considerable quantity of ammoniacal products, which are also worked up into sal ammoniac.

The first attempts made in France to obtain sal ammoniac profitably in this manner, failed. A very extensive factory of the kind, which experienced the same fate, was under the superintendence of the celebrated Baumé, and affords one out of a thousand instances where theoretical chemists have shown their total incapacity for conducting operations on the scale of manufacturing economy. It was established at Gravelle near Charenton, and caused a loss to the shareholders in the speculation of upwards of 400,000 francs. This result closed the concern in 1787, after a foolish manipulation of 27 years. For ten years after that event, all the sal ammoniac consumed in France was imported into it from foreign countries. Since then the two works of MM. Payen and Pluvinet were mounted, and seem to have been tolerably successful. Coal soot was, prior to the introduction of the gas-works, a good deal used in Great Britain for obtaining sal ammoniac. In France, bones and other animal matters are distilled in large iron retorts, for the manufacture of both animal charcoal and sal ammoniac.

These retorts are iron cylinders, 2 or 3 feet in diameter, and 6 feet long. *Figs.* 954, and 955, show the form of the furnace, and the manner in which the cylinders are arranged; the first being a longitudinal, the second a transverse section of it. A, the ash-pits under the grates; B, the fireplaces, arched over at top; C, the vault or bench of fire-bricks, perforated inside with eight flues for distributing the flame; D, a great arch, with a triple voussoir D d', d'', under which the retorts are set. The first arch D, is perforated with twenty vent-holes; the second, with four vent-holes; through which the flame passes to the third arch, and thence to the common chimney-stalk. The retorts *e*, are shut by the door e' (*fig.* 955), luted, and made fast with screw-bolts. Their other ends e'' terminate in tubes *f*, *f*, *f*, which all enter the main pipe *h*. The condensing pipe proceeds slantingly downwards from the further end of *h*, and dips into a large sloping iron cylinder immersed in cold water. See GAS-LIGHT and STOVE, for a better plan of furnace.

954



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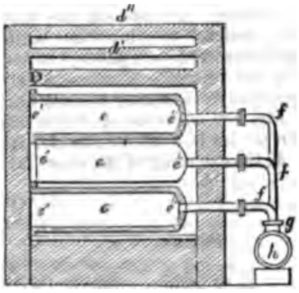

The filters used in the large sal ammoniac works in France are represented in *fig.* 956. The apparatus consists—1. of a wooden chest *a*, lined with lead, and which is turned over at the edges; a socket of lead *b*, soldered into the lowest part of the bottom, serves to discharge the liquid; 2. of a wooden crib or grating formed of rounded rods, as shown in the section *c*, *c*, and the plan *d*; this grating is supported one inch at least above the bottom, and set truly horizontal, by a series of wedges; 3. of an open fabric of canvass or strong calico, laid on the grating, and secured over the edges, so as to keep it tense. A large wooden reservoir *f*, lined with lead, furnished with a

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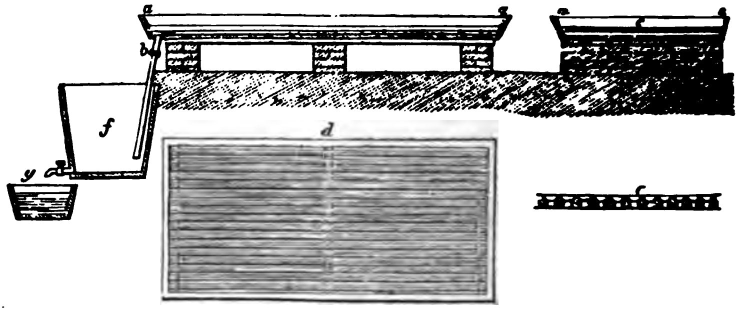


cover, is placed under each of the filters; a pump throws back once or twice upon the filters what has already passed through. A common reservoir *g*, below the others, may be made to communicate at pleasure with one of them, by means of intermediate stop-cocks.

The two boilers for evaporating and decomposing are made of lead, about one quarter of an inch thick, set upon a fire-brick vault, to protect them from the direct action of the flame. Through the whole extent of their bottoms above the vault, horizontal cast-iron plates, supported by ledges and brick compartments, compel the flame and burned air, as they issue from the arch, to percur many sinuosities before they pass up the chimney. This floor of cast iron is intended to support the bottom of the boiler, and to diffuse the heat more equably. The leaden boilers are surrounded with brick-work, and supported at their edges with a wooden frame. They may be emptied at pleasure into lower receivers, called crystallizers, by means of leaden syphons and long-necked funnels.

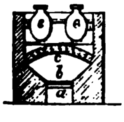
The crystallizers are wooden chests lined with lead, 15 inches deep, 3 or 4 feet broad, and from 6 to 8 feet long; and may be inclined to one side at pleasure. A round cistern receives the drainings of the mother-waters. The pump is made of lead, hardened with antimony and tin.

The subliming furnace is shown in *figs.* 957 and 958, by a transverse and longitudinal section. *a* is the ash-pit; *b*, the grate and fire-place; *c*, the arch above them. This arch, destined to protect the bottles from the direct action of the fire, is perforated with vent-holes, to give a passage to the products of combustion between the subliming vessels. *d*, *d*, are bars of iron, upon which the bottoms of the bottles rest; *e*, stoneware bottles, protected by a coating of loam from the flame.

Fig. 959 shows the cast-iron plates, *a*, *b*, *c*, which, placed above the vaults, receive each two bottles in a double circular opening.

At the extremity of the above furnace, a second one, called the drier, *fig.* 960, receives the

958



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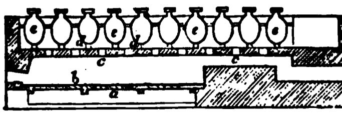

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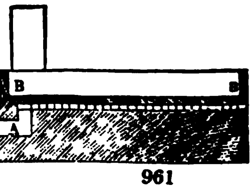

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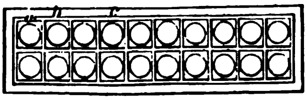
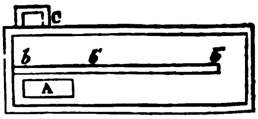


961



products of the combustion of the first, at A, under horizontal cast-iron plates, and upon which the bottom of a rather shallow boiler B, rests. After passing twice under these plates, round a longitudinal brick partition *b*, *b'*, *b''*, the products of combustion enter the smoke chimney C. See plan, *fig.* 961.

The boiler set over this furnace should have no soldered joints. It may be 3½ feet broad, 9 or 10 feet long, and 1 foot deep. The concrete sal ammoniac may be crushed under a pair of edge mill-stones, when it is to be sold in powder.

Bones, blood, flesh, horns, hoofs, woollen rags, silk, hair, scrapings of hides and leather, &c., may be distilled for procuring ammonia. When bones are used, the residuum in the retort is bone black. The charcoal from the other substances will serve for the manufacture of Prussian blue. The bones should undergo a degree of calcination beyond what the ammoniacal process requires, in order to convert them into the best bone black; but the other animal matters should not be calcined up to that point, otherwise they are of little use in the Prussian blue works. If the bones be calcined, however, so highly as to become glazed, their decoloring power on sirups is nearly destroyed. The other substances should not be charred beyond a red-brown heat.

The condensed vapors from the cylinder retorts afford a compound liquor holding carbonate of ammonia in solution, mixed with a large quantity of empyreumatic oil, which floats at top. Lest incrustations of salt should at any time tend to obstruct the tubes, a pipe should be inserted within them, and connected with a steam boiler, so as to blow steam through them occasionally.

The whole liquors mixed have usually a density of 8° or 9° Baumé (1·060). The simplest process for converting their carbonate of ammonia intó muriate, is to saturate them with muriatic acid, to evaporate the solution in a leaden boiler till a pellicle appears, to run it off into crystallizers, and to drain the crystals. Another process is, to decompose the carbonate of ammonia, by passing its crude liquor through a layer of sulphate of lime, 3 or 4 inches thick, spread upon the filters, *fig.* 956. The liquor may be laid on with a pump; it should never stand higher than 1 or 2 inches above the surface of the bruised gypsum, and it should be closely covered with boards, to prevent the dissipation of the volatile alkali in the air. When the liquor has passed through the first filter, it must be pumped upon the second; or the filters being placed in a terrace form, the liquor from the first may flow down upon the second, and thus in succession. The last filter should be formed of nearly fresh gypsum, so as to ensure the thorough conversion of the carbonate into sulphate. The resulting layers of carbonate of lime should be washed with a little water, to extract the sulphate of ammonia interposed among its particles. The ammoniacal liquor thus obtained must be completely saturated, by adding the requisite quantity of sulphuric acid; even a slight excess of acid can do no harm. It is then to be evaporated, and the oil must be skimmed off in the course of the concentration. When the liquid sulphate has acquired the density of about 1·160, sea salt should be added, with constant stirring, till the whole quantity equivalent to the double decomposition be introduced into the lead boiler.

The fluid part must now be drawn off by a syphon into a somewhat deep reservoir, where the impurities are allowed to subside; it is then evaporated by boiling, till the sulphate of soda falls down in granular crystals, as the result of the mutual reaction of the sulphate of ammonia and muriate of soda; while the more soluble muriate of ammonia remains in the liquor. During this precipitation, the whole must be occasionally agitated with wooden paddles; the precipitate being in the intervals removed to the cooler portion of the pan, in order to be taken out by copper rakes and shovels, and thrown into draining-hoppers, placed near the edges of the pan. The drained sulphate of soda must be afterwards washed with cold water, to extract all the adhering sal ammoniac.

The liquor thus freed from the greater part of the sulphate, when sufficiently concentrated, is to be drawn off by a lead syphon, into the crystallizers, where, at the end of 20 or 30 hours, it affords an abundant crop of crystals of sal ammoniac. The mother-water may then be run off, the crystallizers set aslope to drain the salt, and the salt itself must be washed, first by a weak solution of sal ammoniac, and lastly with water. It must be next desiccated, by the apparatus *fig.* 960, into a perfectly dry powder, then put into the subliming stoneware balloons, by means of a funnel, and well rammed down. The mouth of the bottle is to be closed with a plate or inverted pot of any kind. The fire must be nicely regulated, so as to effect the sublimation of the pure salt from the under part of the bottle, with due regularity, into a white cake in the upper part. The neck of the bottle should be cleared from time to time with a long steel skewer, to prevent the risk of choking, and consequent bursting; but in spite of every precaution, several of the bottles crack almost in every operation. In Scotland, sal ammoniac is sublimed in cast-iron pots lined with thin fire-tiles, made in segments accommodated to the internal surface of the pots; the vapor being received and condensed into cakes, within balloons of green glass set over their mouths. The salt, when taken out, and freed by scraping from any adhering ochreous or other impurities, is ready for the market, being sold in hollow spherical masses. The residuum in the pots or bottles may be partially worked up in another operation. The greatest evil is produced by the mixture or even contact of iron, because its peroxyde readily rises in vapor with the sal ammoniac, and tinges it of a red or yellow color.

The most ordinary process for converting the ammoniacal liquor of the gas-works into sal ammoniac, is to saturate it with sulphuric acid, and to decompose the sulphate, thus formed, by the processes above described. But muriatic acid will be preferred, where it is as cheap as sulphuric of equivalent saturating power; because a tolerably pure sal ammoniac is thereby directly obtained. As the coal-gas liquor contains a good deal of sulphureted hydrogen, the saturation of it with acid should be so conducted as to burn the disengaged noxious gases in a chimney. Formerly human urine was very extensively employed, both in this country and in France, in the manufacture of sal ammoniac; but since the general establishment of gas-works, it has been, I believe, abandoned. The process was exceedingly offensive.

The best white sal ammoniac is in spheroidal cakes of about one foot diameter, three or four inches thick in the middle, somewhat thinner at the edges, and is semi-transparent or translucent. Each lump weighs about one quarter of a cwt. As it is easily volatilized by heat, it may be readily examined as to its sophistication with other salts. Sal ammoniac has a certain tenacity, and is flexible under the hammer or pestle. It is principally used in tinning of cast-iron, wrought iron, copper, brass, and for making the various ammoniacal preparations of pharmacy.

In a chemical factory near Glasgow, 7200 gallons of ammoniacal liquor, obtained weekly from the gas-works, are treated as follows:—The liquor is first rectified by distillation from a wagon-shaped wrought-iron boiler, into a square cistern of iron lined with lead. 4500 lbs. of sulphuric acid, of specific gravity 1·625, are then slowly added to the somewhat concentrated distilled water of ammonia. The produce is 2400 gallons of sulphate of ammonia, slightly acidulous, of specific gravity 1·150, being of such strength as to deposite a few crystals upon the sides of the lead-lined iron tank in which the saline combination is made. It is decomposed by common salt.

From the 7200 gallons of the first crude liquor, 900 gallons of tar are got by subsidence, and 200 gallons of petroleum are skimmed off the surface. The tar is converted, by a moderate boiling in iron pans, into good pitch.

SALAMSTONE. See Lapidary.

SALEP, or SALOUP, is the name of the dried tuberous roots of the *Orchis*, imported from Persia and Asia Minor, which are the product of a great many species of the plant, but especially of the *Orchis mascula*. Salep occurs in commerce in small oval grains, of a whitish-yellow color, at times semi-transparent, of a horny aspect, very hard, with a faint peculiar smell, and a taste like that of gum tragacanth, but slightly saline. These are composed almost entirely of starchy matter, well adapted for making a thick pap with water or milk, and are hence in great repute in the Levant, as restorers of the animal forces. Their aphrodisiacal properties are apocryphal. If the largest roots of the *Orchis mascula* of our own country were cleaned, scraped, steeped for a short time in hot, and then for a few minutes in boiling water, to extract their rank flavor, afterwards suspended upon strings to dry in the air, they would afford as nourishing and palatable an article as the Turkey saloup, and at a vastly lower price.

SALICINE, is a febrifuge substance, which may be obtained in white pearly crystals from the bark of the white willow (*Salix alba*), of the aspen tree (*Salix helis*), as also of some other willows, and some poplars. It has a very bitter taste.

SAL PRUNELLA, is fused nitre cast into cakes or balls.

SAL VOLATILE, is sesquicarbonate of ammonia.

SALT, EPSOM, is sulphate of magnesia.

SALT, MICROCOSMIC, is the triple phosphate of soda and ammonia.

SALT OF AMBER, is succinic acid.

SALT OF LEMONS, is citric acid.

SALT OF SATURN, is acetate of lead.

SALT OF SODA, is carbonate of soda.

SALT OF SORREL, is bi-oxalate of potassa.

SALT OF TARTAR, is carbonate of potassa.

SALT OF VITRIOL, is sulphate of zinc.

SALT PERLATE, is phosphate of soda.

SALTPETRE, is nitre, or nitrate of potassa.

SALT, SEDATIVE, is boracic acid.

SALTS, are an important class of chemical compounds, anciently studied under the Greek title of *Halurgy*. At one period every inorganic substance readily soluble in water, was regarded as a salt; and afterwards, every substance soluble in five hundred times its weight of water. Thus both acid and alkaline bodies came to be enrolled among salts; but latterly, the combinations of the acids with alkalis, earths, and metallic calces (now styled oxydes), were alone thought to be entitled to the denomination of salts, in consequence of their resemblance in appearance, and supposed analogy in composition, to culinary salt. Since Sir H. Davy demonstrated that this substance contained neither acid nor alkaline matter, but that it consisted of chlorine and the metal sodium, the generality of chemists found it impossible to include salts under one category of constitation; while a few have rashly offered to cut the knot, by excluding from the saline family, chloride of sodium, the patriarch of the whole.

Salts may be justly divided into three orders:

1. The binary, consisting of two single members; such as the bromides, chlorides, cyanides, fluorides, iodides, carburets, phosphurets, sulphurets, &c.

2. The bi-binary, consisting of two double members; such as the borates, bromates, carbonates, chlorates, sulphates, sulphites, hyposulphites, sulphohydrates, &c.

3. The ternary, consisting of two single members of one genus, and one member of another; such as the boro-fluorides, silico-fluorides, sulpho-cyanides, chloriodides, &c.

The species of each order may exist in three states, constituting neutral salts, supersalts, and subsalts; as for example, the chloride of sodium, the bisulphate of potassa, the subnitrate of lead, &c.

In the above arrangement, cyanogen is allowed to represent a simple substance, from its forming analogous compounds with chlorine and iodine. The neutral state of salts is commonly indicated by their solutions not changing the colors of litmus, violets, or red cabbage; the sub-state of salts, by their turning the violet and cabbage green; and the super-state of salts, by their changing the purple of litmus, violets, and cabbage, red; but to the generality of this criterion there are some exceptions. The atomic theory may be advantageously resorted to, in this predicament. 1. When one prime equivalent of the one member (whether single or double) of a salt, combines with one prime of the other member, a neutral salt is the result, as in chloride of sodium or nitrate of potassa. 2. When two primes of the electro-negative member combine with one prime of the electro-positive, a supersalt is formed, as bichloride of tin, or bisulphate of potassa. 3. When one prime of the electro-negative member combines with two or more primes of the electro-positive, a subsalt is produced, as the subacetate and subchromate of lead, &c.

SALT, SEA, or CULINARY; *chloride of sodium; muriate of soda.* (*Hydrochlorate de soude*, Fr.; *Chlornatrium*, Germ.) Sea salt, or rock salt, in a state of purity, consists of 60 of chlorine + 40 of sodium, in 100 parts.

This important species of the saline class possesses, even in mass, a crystalline structure, derived from the cube, which is its primitive form. It has generally a foliated texture, and a distinct cleavage; but it has also sometimes a fibrous structure. The massive salt has a vitreous lustre. It is not so brittle as nitre; it is nearly as hard as alum, a little harder than gypsum, and softer than calcareous spar. Its specific gravity varies from 2·0 to 2·25. When pure, it is colorless, translucent, or transparent. On exposure to heat, it commonly decrepitates; but some kinds of rock salt enter quietly into fusion at an elevated temperature, a circumstance which has been ascribed to their having been originally subjected to the action of fire.

According to M. Gay Lussac, 100 parts of water dissolve—

35·81	parts of the salt, at temperature	57·0° Fahr.
35·88	—	62·5°
37·14	—	140·0°
40·38	—	229·5°

Native chloride of sodium, whether obtained from the waters of the ocean, from saline lakes, from salt springs, or mineral masses, is never perfectly pure. The foreign matters present in it vary with its different origins and qualities. These are, the sulphates of lime, magnesia, soda, muriates of magnesia and potash, bitumen, oxyde of iron, clay in a state of diffusion, &c.

Muriate of potash has been detected, in the waters of the ocean, in the sal-gem of Berchtesgaden in Bavaria, of Hallein in the territory of Salzbourg, and in the salt springs of Rosenheim.

The more heterogeneous the salt, the more soluble is it, by the reciprocal affinity of its different saline constituents; and thus a delicate hydrometer, plunged in saturated brine, may serve to show approximately the quality of the salt. I find that the specific gravity of a saturated solution of large-grained cubical salt, is 1·1962 at 60° F. 100 parts of this brine contain 25½ of salt, (100 w. + 34·2 s.) From mutual penetration, 100 volumes of the aqueous and saline constituents form rather less than 96 of the solution.

Among the varieties in the form of this salt, the octahedral, the cubo-octahedral, and the dodecahedral, have been mentioned; but there is another, called the funnel or hopper-shaped, which is very common. It is a hollow rectangular pyramid, which forms at the surface of the saline solution in the course of its evaporation, commencing with a small floating cube, upon which lines of other little cubes attach themselves to the edges of the upper face; whereby they form and enlarge the sides of a hollow pyramid, whose apex, the single cubic crystal, is downward. This sinks by degrees as the aggregation goes on above, till a pyramidal boat of considerable size is constructed.

A TABLE of the results of the ANALYSES of several varieties of CULINARY SALT.

Origin of the Salt.	Chloride of Sodium.	Muriate of Magnesia.	Muriate of Lime.	Sulphate of Soda.	Sulphate of Magnesia.	Sulphate of Lime.	Clay and other insoluble bodies.	Oxyde of iron.
Sal-gem of Vic { white	99·30	—	—	—	—	0·005	0·020	
Sal-gem of Vic { red	99·80	—	—	—	—	—	0·002	
——— Cheshire, crushed - -	98·33	0·02	—	—	—	0·65	—	0·002
Salt from Salt Springs :								
Schönbeck, Westphalia	93·90	0·30	—	1·00	—	0·80		
Moutiers { des cordes	97·17	0·25	—	2·00	0·58			
Moutiers { boilers	93·59	0·61	—	5·55	0·25			
Château Salins -	97·82	2·12						
White of Sulz - -	96·88	3·12						
Ludwigshall, middle grained -	99·45	—	—	0·05	—	0·28		
Kœnigsborn, Westphalia	95·90	—	0·27	—	—	1·10		
Sea salt, half white -	97·20	0·004	—	—	0·050	0·120	0·070	
———, of Saint Malo	96·	0·30	—	—	0·45	2·35		
Common Scottish salt	93·55	2·80	—	—	1·75	1·50		
Lymington, common -	93·7	1·1	—	—	3·50	1·50	2·00	
————, cat -	98·8	0·5	—	—	0·5	0·1		
Cheshire, stoved -	98·25	0·075	0·025	—	—	1·55		

The geological position of rock salt is between the coal formation and the lias. The great rock-salt formation of England occurs within the *red marl*, or new red sandstone, the *bunter-sandstein* of the Germans, so called, because its colors vary from red to salmon and chocolate. This mineral stratum frequently presents streaks of light blue, verdigris, buff, or cream color; and is chiefly remarkable for containing considerable masses or beds of gypsum. At Northwich, in the vale of the Weaver, the rock salt consists of two beds, together not less than 60 feet thick, which are supposed to constitute large insulated masses, about a mile and a half long, and nearly 1300 yards broad. There are other deposites of rock salt in the same valley, but of inferior importance. The uppermost bed occurs at 75 feet beneath the surface, and is covered with many layers of indurated red, blue, and brown clay, interstratified more or less with sulphate of lime, and interspersed with argillaceous marl. The second bed of rock salt lies 31½ feet below the first, being separated from it by layers of indurated clay, with veins of rock salt running through them. The lowest bed of salt was excavated to a depth of 110 feet, several years ago.

The beds or masses of rock salt are occasionally so thick, that they have not been yet bored through, though mined for many centuries. This is the case with the immense mass of Wieliczka, and the lower bed at Northwich. But in ordinary cases, this thickness varies from an inch or two to 12 or 15 yards. When the strata are thin, they are usually numerous; but the beds, layers, or masses never exhibit throughout a great extent any more than an illusory appearance of parallelism; for when they are explored at several points, enlargements are observed, and such diminutions as cause the salt to disappear sometimes altogether. This mineral is not deposited, therefore, in a geological stratum, but rather in lenticular masses, of very variable extent and thickness, placed alongside of each other at unequal distances, and interposed between the courses of the other formations.

Sometimes the rock salt is disseminated in small masses or little veins among the calcareous and argillaceous marls which accompany or overlie the greater deposites. Bitumen, in small particles, hardly visible, but distinguishable by the smell, occurs in all the minerals of the saliferous system.

It has been remarked, that the plants which grow generally on the sea shores, such as the *Triglochinum maritimum*, the *Salicornia*, the *Salsola kali*, the *Aster trifolium*, or farewell to summer, the *Glaux maritima*, &c., occur also in the neighborhood of salt mines and salt springs, even of those which are most deeply buried beneath the surface.

The interior of rock-salt mines, after digging through the strata of clay marl, &c. is extremely dry; so that the dust produced in the workings becomes an annoyance to the miners, though in other respects the excavations are not at all insalubrious.

Salt springs occur nearly in the same circumstances, and in the same geological formation as the salt rock. It has been noticed that salt spings issue, in general, from the upper portion of the saliferous strata, principally from the saline clay marls. Cases however occur, where the salt springs are not accompanied by rock salt, and where the whole saline matter is derived from the marls themselves, which thus constitute the only saliferous beds.

It has been imagined that there are two other periods of geological formation of this substance; one much more ancient, belonging to the transition series of rocks; the other relatively modern, among secondary strata. To the former has been referred the salt formation of Bex, that of Cardonne, &c. But M. Brongniart assigns valid reasons for rejecting this supposition. M. Beudant, indeed, refers to the secondary strata above the chalk, the rock-salt formation of Wieliczka, and of the base of the Carpathians; placing these among the plastic clay and lignites.

The mines of rock salt do not appear to possess any determinate elevation upon the surface of the earth. Immense masses of it are met with at very great depths below the level of the sea, (the mine of Wieliczka is excavated 860 feet beneath the soil,) and others exist at a considerable altitude, as that of Hallein near Salzbourg, which is 3300 feet above the level of the sea, and the saline rock of Arbonne in Savoy, which is nearly 4000 feet higher, situated at the great elevation of 7200 feet above the level of the sea, and consequently in the region of perpetual snow. The rock is a mass of saccharoid and anhydrous gypsum, imbued with common salt, which is extracted by lixiviation; after which the gypsum remains porous and light.

The inland seas, salt lakes, and salt marshes, have their several localities obviously independent of peculiar geological formations. The ocean is, however, the most magnificent mine of salt, since this chloride constitutes about one thirtieth part of its weight; being pretty evenly diffused throughout its waters, when no local cause disturbs the equilibrium. The largest proportion of salt held in solution in the open sea, is 38 parts in 1000, and the smallest 32. In a specimen taken by Mr. Wilkinson, out of the Red Sea, at Berenice, I found 43 parts of salt in 1000. The specific gravity of the water was 1·035.

Were it requisite to extract the chloride of sodium from sea-water by fuel alone, many countries, even maritime, would find the process too costly. The salt is therefore obtained from it in two different manners; 1. by natural evaporation alone; 2. by natural and artificial evaporation combined. The first method is employed in warm regions, under the form of saline tanks, or brine reservoirs, called also brine-pits. These are large shallow basins, the bottom of which is very smooth, and formed of clay. They are excavated along the sea-shore, and consist of—

1st. A large reservoir, deeper than the proper brine-pits, which is dug between them and the sea. This reservoir communicates with the sea by means of a channel provided with a sluice. On the sea-shore, these reservoirs may be filled at high water, though the tides are rather inconvenient than advantageous to brine-pits.

2dly. The brine-pits, properly so called, which are divided into a number of compartments by means of little banks. All these compartments have a communication with each other, but so that the water frequently has a long circuit to make, from one set to another. Sometimes it must flow 400 or 500 yards, before it reaches the extremity of this sort of labyrinth. The various divisions have a number of singular names, by which they are technically distinguished. They should be exposed to the north, north-east, or northwest winds.

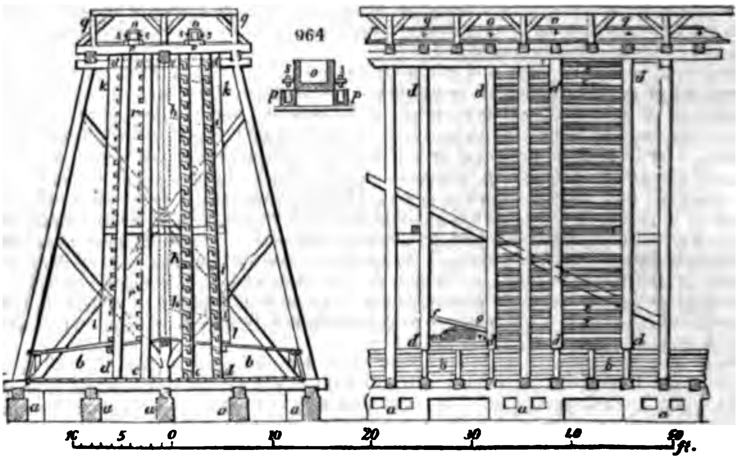
The water of the sea is let into these reservoirs in the month of March, where it is exposed on a vast surface to evaporation. The first reservoir is intended to detain the water till its impurities have subsided, and from it the other reservoirs are supplied, as their water evaporates. The salt is considered to be on the point of crystallizing when the water begins to grow red. Soon after this, a pellicle forms on the surface, which breaks, and falls to the bottom. Sometimes the salt is allowed to subside in the first compartment; at others, the strong brine is made to pass on to the others, where a larger surface is exposed to the air. In either case the salt is drawn out, and left upon the borders to drain and dry.

The salt thus obtained partakes of the color of the bottom on which it is formed; and is hence white, red, or gray.

Sea water contains, in 1000 parts, 25 of chloride of sodium, 5·3 sulphate of magnesia, 3·5 chloride of magnesium, 0·2 carbonate of lime and magnesia, 0·1 sulphate of lime, besides $\frac{1}{2000}$ of sulphate and muriate of potash. It also contains iodide of sodium, and bromide of magnesium. Its average spec. grav. is from 1·029 to 1·030.

Sea-water and weak brines may be cancentrajed either by the addition of rock salt, by spontaneous evaporation in brine-pits (see *suprà*), or by graduation. Houses for the last purpose are extensively employed in France and Germany. The weak brine is pumped into an immense cistern on the top of a tower, and is thence allowed to flow down the surface of bundles of thorns built up in regular walls, between parallel wooden frames. At Salza, near Schönebeck, the graduation-house is 5817 feet long, the thorn walls are from 33 to 52 feet high, in different parts, and present a total surface of 25,000 square feet. Under the thorns, a great brine cistern, made of strong wooden planks, is placed, to receive the perpetual shower of water. Upon the ridge of the graduation-house there is a long spout, perforated on each side with numerous holes, and furnished with spigots or stopcocks for distributing the brine, either over the surface of the thorns, or down through their mass; the latter method affording larger evaporation. The graduation-house should be built lengthwise in the direction of the prevailing wind, with its ends open. An experience of many years at Salza and Dürrenberg has shown, that in the former place graduation can go on 258, and in the latter 207 days, on an average, in the year; the best season being from May till August. At Dürrenberg, 3,596,561 cubic feet of water are evaporated annually. According to the weakness of the brine, it must be the more frequently pumped up, and made to flow down over the thorns in different compartments of the building, called the 1st, 2d, and 3d graduation. A deposite of gypsum incrusts the twigs, which requires them to be renewed at the end of a certain time. *Figs.* 962 and 963 represent the graduation-house of the salt-works at Dürrenberg. *a*, *a*, *a*, are low stone pillars for supporting the brine cistern *b*, called the *soole-schiff*. *c*, *c* are the inner, *d*, *d* the outer, walls of thorns; the first have perpendicular sides, the last sloping. The spars *e*, *e*, which support the thorns, are longer than the interval between two thorn walls from *f* to *g*, *fig*. 963, whereby they are readily fastened by their tenons and mortises. The spars are laid at a slope of 2 inches in the foot, as shown by the line *h*, *i*. The bundles of thorns are each 1½ foot thick, from 5 to 7 feet long, and are piled up in the following way: — Guide-bars are first placed in the line *k*, *l*, to define the outer surface of the thorn wall; the undermost spars *m*, *n*, are fastened upon them; and the thorns are evenly spread, after the willow-withs of the bundles have been cut. Over the top of the thorn walls are laid, through the whole length of the graduation-house, the brine spouts *o*, *o*, which are secured to the upper beams; and at both sides of these spouts are the drop-spouts *p*, *p*, for discharging the brine by the spigots *s*, *s*, as shown upon a larger scale in *fig*. 964. The drop-spouts are 6 feet long, have on each side small notches, 5 inches apart, and are each supplied by a spigot. The space above the ridge of the graduation-house is covered with boards, supported at their ends by binding-beams *q*. *r*, *r*, show the tenons of the thorn-spars. Over the soole-schiff *b*, inclined planes of boards are laid for conducting downwards the innumerable showers. The brine, which contains at first 7·692 per cent. of salt, indicates, after the first shower, 11·473; after the second, 16·108; and after the third, 22. The brine, thus concentrated to such a degree as to be fit for boiling, is kept in great reservoirs, of which the eight at Salza, near Schönebeck, have a capacity of 2,421,720 cubic feet, and are furnished with pipes leading to the sheet-iron salt-pans. The capacity of these is very different at different works. At Schönebeck there are 22, the smallest having a square surface of 400 feet, the largest of 1250, and are enclosed within walls, to prevent their being affected by the cold external air. They are covered with a funnel-formed or pyramidal trunk of deals, ending in a square chimney, to carry off the steam.

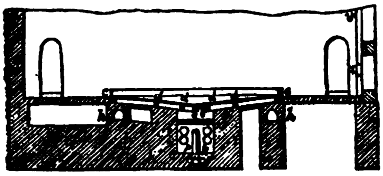
962 963



Figs. 965, 966, 967 represent the construction of a salt-pan, its furnace, and the salt store-room of the works at Dürrenberg; *fig*. 967 being the ground plan, *fig*. 966

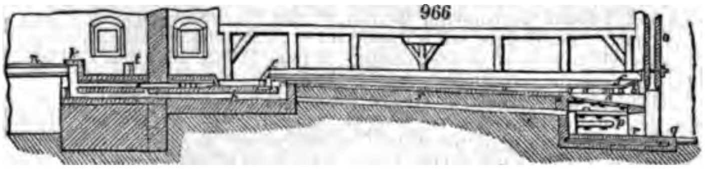
the longitudinal section, and *fig.* 965 the transverse section. *a* is the fire-grate, which slopes upwards to the back part, and is 31½ inches distant from the bottom of the pan. The ratio of the surface of the grate to that of the bottom of the pan, is as 1 to 59·5; that of the air-hole into the ash-pit, as 1 to 306. The bed under the pan is laid with bricks, smoothly plastered over, from *b* to *c*, in *fig.* 966. Upon this bed the pillars *d*, *d*, &c., are built in a radiated direction, being 6 inches broad at the bottom, and tapering to 1½ inch at top. The pan is so laid that its bottom has a fall towards the middle of 2½ inches; see *e*, *f*, *fig.* 966. The fire diffuses itself in all directions under the pan, proceeds thence through several holes *g*, *g*, *g*, into flues *h*, *h*, *h*, which run round three sides of the pan; the burnt air then passes through *i*, *fig.* 967, under other pans, from which it is collected in the chimneys *k*, *k*, to be conducted into the drying-room. At *l*, *l*, there is a transverse flue, through which, by means of dampers, the fire-draught may be conducted into an extra chimney *m*. From the flues *k*, *k*, four square iron pipes *n*, *n*, issue and conduct the burnt air into the main chimneys in the opposite wall.

965

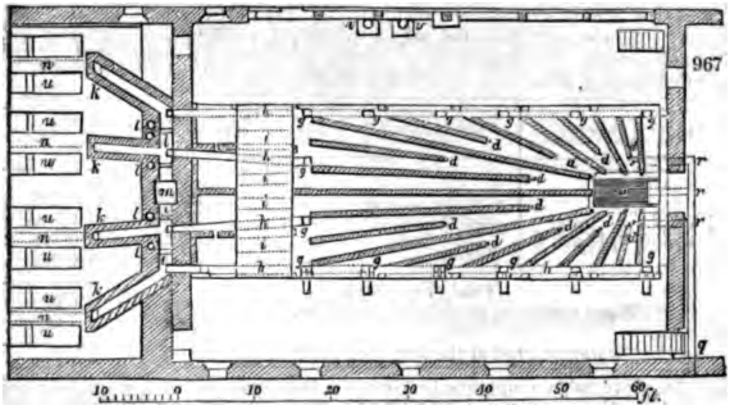


The bottoms of the several flues have a gradual ascent above the level of the fire-grate. A special chimney *o*, rises above the ash-pit, to carry off the smoke, which may chance to regurgitate in certain states of the wind. *p*, *p*, are iron pipes laid upon each side of the ash-pit (see *figs.* 966 and 967), into which cold air is admitted by the flue *q*, *r* where, becoming heated, it is conducted through iron pipes *s*, and thence escapes at *t*, into the stove-room. Upon both sides of the hot flues in the stove-room, hurdle-frames *u*, *u*, are laid, each of which contains 11 baskets, and every basket, except the undermost, holds 60 pounds of salt, spread in a layer 2 inches thick. *v*, *v*, show the pipes by which the pan is supplied with graduated brine.

966

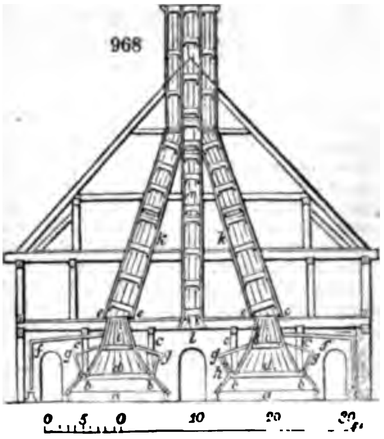


967



Description of the Steam-trunk, in fig. 968.

In front of the pan *a*, *a*, there are two upright posts, upon which, and in holes of the back wall, two horizontal beams *b*, *b*, are supported. The pillars *c*, *c*, are sustained upon the bearers *d*, *d*. At *e*, *e*, a deep quadrangular groove is made in the beams, for fixing down the four boards which form the bottom of the steam-way. In this groove any condensed water from the steam collects, and is carried off by a pipe *f*, to prevent it falling back into the pan. Upon the three sides of the pan not in contact with the wall, there are three rows of boards hinged upon planks *b*, *b*. Behind the upper one, a board is hung on at *g*, upon which the boiled salt is laid to drain. The two other rows of boards are hooked on so as to cover the pan, as shown at *h*. Whenever the salt is sufficiently drained, the upper shelves are placed in a horizontal position; the salt is put into small baskets, and carried into the stove-room. *i*, *k*, is the steam-trunk; *l*, *m*, is a tunnel for carrying off the steam from the middle of the pan, when this is uncovered by lifting the boards.



In proportion as the brine becomes concentrated by evaporation, more is added from the settling reservoir of the graduation-house, till finally small crystals appear on the surface. No more weak brine is now added, but the charge is worked off, care being taken to remove the scum as it appears. In some places the first pan is called a schlot-plan, in which the concentration is carried only so far as to cause the deposition of the sludge, from which the saline solution is run into another pan, and gently evaporated, to produce the precipitation of the fine salt. This salt should be continually raked towards the cooler and more elevated sides of the pan, and then lifted out with cullender-shovels into large conical baskets, arranged in wooden frames round the border of the pan, so that the drainage may flow back into the boiling liquor. The drained salt is transferred to the hurdles or baskets in the stove-room, which ought to be kept at a temperature of from 120° to 130° Fahr. The salt is then stowed away in the warehouse.

The graduation range should be divided lengthwise into several sections; the first to receive the water of the spring, the lake, or the sea; the second, the water from the first shower-receiver; the third, the water from the second receiver; and so on. The pumps are usually placed in the middle of the building, and lift the brine from the several receivers below into the alternate elevated cisterns. The square wooden spouts of distribution may be conveniently furnished with a slide-board, attached to each of their sides, to serve as a general valve for opening or shutting many trickling orifices at once. The rate of evaporation at Moutiers is exhibited by the following table:—

Number of Showers.	Total Surface of the Fagots.	Specific Gravity of the Brine.	Water evaporated.
		1·010	0·000
1 and 2 - -	5158 square feet - -	1·023	0·540
3, 4, 5, 6, 7, 8, and 9 -	2720 - - -	1·072	0·333
10 - - -	550 - - -	1·140	0·062
	Total evaporation - - -		0·935
	Water remaining in the brine at the density of 1·140 -		1·065
	Water assigned at the density of 1·010 - -		1·000

From the above table it appears that no less than 10 falls of the brine have been required to bring the water from the specific gravity 1·010 to 1·140, or 18° Baumé. The evaporation is found to proceed at nearly the same rate with the weaker water, and with the stronger, within the above limits. When it arrives at a density of from 1·140 to 1·16, it is run off into the settling cisterns. M. Berthier calculates, that upon an average, in ordinary weather, at Moutiers, 60 kilogrammes of water (13 gallons, imp.) are evaporated from the fagots, in the course of 24 hours, for every square foot of their surface. Without the aid of currents of air artificially warmed, such an amount of evaporation could not be reckoned upon in this country. In the *schlotting*, or throwing down of the sediment, a little bullock's blood, previously beaten up with some cold brine, promotes the clarification. When the brine acquires, by brisk ebullition, the density of 1·200, it should be run off from the preparation, to the finishing or salting pans.

The mother-water contains a great deal of chloride of magnesium, along with chloride of sodium, and sulphate of magnesia. Since the last two salts mutually decompose each other at a low temperature, and are transformed into sulphate of soda, which crystallizes, and muriate of magnesia, which remains dissolved, the mother-water with this view may be exposed in tanks to the frost during winter, when it affords three successive crystalline deposites, the last being sulphate of soda, nearly pure.

The chloride of magnesium, or bittern, not only deteriorates the salt very much, but occasions a considerable loss of weight. It may, however, be most advantageously got rid of, and converted into chloride of sodium, by the following simple expedient: — Let quicklime be introduced in equivalent quantity to the magnesia present, and it will precipitate this earth, and form chloride of calcium, which will immediately react upon the sulphate of soda in the mother-water, with the production of sulphate of lime and chloride of sodium. The former being sparingly soluble, is easily separated. Lime, moreover, decomposes directly the chloride of magnesium, but with the effect of merely substituting chloride of calcium in its stead. But in general there is abundance of sulphate of soda in brine springs to decompose the chloride of calcium. A still better way of proceeding with sea-water, would be to add to it, in the settling tank, the quantity of lime equivalent to the magnesia, whereby an available deposite of this earth would be obtained, at the same time that the brine would be sweetened. Water thus purified may be safely crystallized by rapid evaporation.

In summer, the saturated boiling brine is crystallized by passing it over vertical ropes; for which purpose 100,000 metres (110,000 yards) are mounted in an apartment 70 metres (77 yards) long. When the salt has formed a crust upon the ropes about 2½ inches thick, it is broken off, allowed to fall upon the clean floor of the apartment, and then gathered up. The salting of a charge, which would take 5 or 6 days in the pan, is completed in this way in 17 hours; but the mother-waters are more abundant. The salt is, however, remarkably pure.

The boilers constructed at Rosenheim, in Bavaria, evaporate 3¼ pounds of water for every pound of wood burned; which is reckoned a favorable result; but some of those described under EVAPORATION, would throw off much more.

"The rock salt mines and principal brine springs are in Cheshire; and the chief part of the Cheshire salt, both fossil and manufactured, is sent by the river Weaver to Liverpool, a very small proportion of it being conveyed elsewhere, by canal or land carriage. There are brine springs in Staffordshire, from which Hull is furnished with white salt; and in Worcestershire, from which Gloucester is supplied. If to the quantity shipped by the Weaver, 100,000 tons of white salt are added annually for internal consumption and exports, exclusive of Liverpool, the total manufacture will be approached very nearly; but as there is now no check from the excise, it is impossible to ascertain it exactly. Fossil salt is used in small quantities at some of the Cheshire manufactories, to strengthen the brine, but is principally exported; some to Ireland, but chiefly to Belgium and Holland."* The average quantity of rock salt sent annually down the river Weaver, from the mines in Cheshire, between the years 1803 and 1834 inclusive, was 86,000 tons, of 2,600 lbs. each; the greatest being 125,658, in the year 1823, and the least 47,230, in the year 1813. The average quantity of white salt sent annually down the Weaver from the manufactories in Cheshire during the same period, was 221,351; the greatest being 383,669, in the year 1832, and the least being 120,486, in the year 1811.

M. Clement-Desormes, engineer and chief *actionnaire* of the great salt-works of Dieuze, in France, informs me that the internal consumption of that kingdom is rather more than 200,000 tons per annum, being at the rate of 6½ kilogrammes for each individual of a population estimated at 32,000,000. As the retail price of salt in France is 10 sous per kilogramme (of 2½ lbs. avoird.), while in this country it is not more than 2 sous (1 penny), its consumption per head will be much greater with us; and, taking into account the immense quantity of salted provisions that are used, it may be reckoned at 22 lbs.; whence our internal consumption will be 240,000 tons, instead of 100,000, as quoted above, from the tables published by the Board of Trade.

In 1836, 9,622,427 bushels, of 56 lbs. = 240,560 tons of salt, value 173,923*l*., were exported from the United Kingdom, of which 1,350,849 bushels went to Russia; 1,235,086 to Belgium; 314,132 to the Western coast of Africa; 1,293,560 to the British North American colonies; 2,870,808 to the United States of America; 53,299 to New South Wales, Van Diemen's Land, and other Australian settlements; 58,735 to the British West Indies; and 90,655 to Guernsey, Jersey, Alderney, and Man.

SAND (Eng. and Germ.; *Sable*, Fr.), is the name given to any mineral substance in a hard granular or pulverulent form, whether strewed upon the surface of the ground, found in strata at a certain depth, forming the beds of rivers, or the shores of the sea. The silicious sands seem to be either original crystalline formations, like the sand of Neuilly, in 6-sided prisms, terminated by two 6-sided pyramids, or the *débris* of granitic, schistose, quartzose, or other primitive crystalline rocks, and are abundantly distributed ver the globe; as in the immense plains known under the names of downs, deserts, *teppes*, *iandes*, &c., which, in Africa, Asia, Europe, and America, are entirely covered with loose sterile sand. Valuable metallic ores, those of gold, platinum, tin, copper, iron, titanium, often occur in the form of sand, or mixed with that earthy substance. Pure silicious sands are very valuable for the manufacture of glass, for making mortars, filters, ameliorating dense clay soils, and many other purposes. For moulder's sand, See Founding. Lynn and Ryegate furnish our purest silicious sand.

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* Tables of the Revenue, Population, Commerce, &c., for 1835, p. 122.

SANDAL or RED SAUNDERS WOOD (*Santal*, Fr.; *Sandelholz*, Germ.), is the wood of the *Pterocarpus santalinus*, a tree which grows in Ceylon, and on the coast of Coromandel. The old wood is preferred by dyers. Its coloring matter is of a resinous nature; and is, therefore, quite soluble in alcohol, essential oils, and alkaline leys; but sparingly in boiling water, and hardly if at all in cold water. The coloring matter which is obtained by evaporating the alcoholic infusion to dryness, has been called *santaline;* it is a red resin, which is fusible at 212° F. It may also be obtained by digesting the rasped sandal wood in water of ammonia, and afterwards saturating the ammonia with an acid. The *santaline* falls, and the supernatant liquor, which is yellow by transmitted, appears blue by reflected light. Its spirituous solution affords a fine purple precipitate with the protochloride of tin, and a violet one with the salts of lead. Santaline is very soluble in acetic acid, and the solution forms permanent stains upon the skin.

Sandal wood is used in India, along with one tenth of *sapan* wood (the *Cæsalpinia sapan* of Japan, Java, Siam, Celebes, and the Philippine isles), principally for dyeing silk and cotton. Trommsdorf dyed wool, cotton, and linen a carmine hue by dipping them alternately in alkaline solution of the sandal wood, and in an acidulous bath. Bancroft obtained a fast and brilliant reddish-yellow, by preparing wool with an alum and tartar bath, and then passing it through a boiling bath of sandal wood and sumac. Pelletier did not succeed in repeating this experiment. According to Togler, wool, silk, cotton, and linen, mordanted with salt of tin, and dipped in a cold alcoholic tincture of the wood, or the same tincture mixed with 8 parts of boiling water, become of a superb ponçeau-red color. With alum, they took a scarlet-red; with sulphate of iron, a deep violet, or brown-red. Unluckily, these dyes do not stand exposure to light well.

SANDARACH, is a peculiar resinous substance, the product of the *Thuya articulata*, a small tree of the coniferous family, which grows in the northern parts of Africa, especially round Mount Atlas.

The resin comes to us in pale yellow, transparent, brittle, small tears, of a spherical or cylindrical shape. It has a faint aromatic smell, does not soften, but breaks between the teeth, fuses readily with heat, and has a specific gravity of from 1·05 to 1·09. It contains three different resins; one soluble in spirit of wine, somewhat resembling *pinic acid* (see Turpentine); one not soluble in that menstruum; and a third, soluble only in alcohol of 90 per cent. It is used as pounce-powder for strewing over paper erasures, as incense, and in varnishes.

SAPAN WOOD, is a species of the *Cæsalpinia* genus, to which Brazil wood belongs. It is so called by the French, because it comes to them from Japan, which they corruptly pronounce Sapan. As all the species of this tree are natives of either the East Indies or the New World, one would imagine that they could not have been used as dye-stuffs in Europe before the beginning of the 16th century. Yet the author of the article "Brazil," in Rees' Cyclopædia, and Mr. Southey, in his History of Brazil, say that *Brazil* wood is mentioned nearly one hundred years before the discoveries of Columbus and Vasco de Gama, by Chaucer, who died in 1400; that it was known many ages before his time; and that it gave the name to the country, instead of the country giving the name to the wood, as I have stated, with Berthollet and other writers on dyeing. The *Cæsalpinia sappan*, being a native of the Coromandel coast, may *possibly* have been transported along with other Malabar merchandise to the Mediterranean marts in the middle ages; but the importation of so lumbering an article in any considerable quantity by that channel, is so improbable, that I am disposed to belive that Brazil wood was not commonly used by the dyers of Europe before the discovery of the New World.

SARD; see Lapidary.

SATIN (Eng., Fr., and Germ.), is the name of a silk stuff, first imported from China, which is distinguished by its very smooth, polished, and glossy surface. It is woven upon a loom with at least five-leaved healds or heddles, and as many corresponding treddles. These are so mounted as to rise and fall four at a time, raising and depressing alternately four yarns of the warp, across the whole of which the weft is thrown by the shuttle, so as to produce a uniform smooth texture, instead of the checkered work resulting from intermediate decussations, as in common webs. See Textile Fabrics. Satins are woven with the glossy or right side undermost, because the four-fifths of the warp, which are always left there during the action of the healds, serve to support the shuttle in its race. Were they woven in the reverse way, the scanty fifth part of the warp threads would either not support, or would be too much worn by the shuttle.

SATURATION is the term at which any body has taken its full dose or chemical proportion of any other with which it can combine; as water with a salt, or an acid with an alkali in the neutro-saline state.

SCALIOLA is merely ornamental plaster-work, produced by applying a pap made of finely-ground calcined gypsum, mixed with a weak solution of Flanders' glue, upon any figure formed of laths nailed together, or occasionally upon brickwork, and bestudding its surface, while soft, with splinters (*scagliole*) of spar, marble, granite, bits of concrete colored gypsum, or veins of clay, in a semi-fluid state. The substances employed to color the spots and patches, are the several ochres, boles, *terra di Sienna*, chrome yellow, &c. The surface of the column is turned smooth upon a lathe, polished with stones of different fineness, and finished with some plaster-pap, to give it lustre. Pillars and other flat surfaces are smoothed by a carpenter's plane, with the chisel finely serrated, and afterwards polished with plaster by friction. The glue is the cause of the gloss, but makes the surface apt to be injured by moisture, or even damp air.

SCARLET DYE. (*Teinture en écarlate*, Fr.; *Scharlachfärberei*, Germ.) Scarlet is usually given at two successive operations. The boiler (see *figs.* 364, 365, article DYEING) is made of block tin, but its bottom is formed occasionally of copper.

1. *The bouillon, or the coloring-bath.*—For 100 pounds of cloth, put into the water, when it is little more than lukewarm, 6 pounds of argal, and stir it well. When the water becomes too hot for the hand, throw into it, with agitation, one pound of cochineal in fine powder. An instant afterwards, pour in 5 pounds of the clear mordant G (see TIN MORDANTS), stir the whole thoroughly as soon as the bath begins to boil, introduce the cloth, and wince it briskly for two or three rotations, and then more slowly. At the end of a two-hours' boil, the cloth is to be taken out, allowed to become perfectly cool, and well washed at the river, or winced in a current of pure water. (See an automatic plan of washing described under the article RINSING MACHINE.)

2. *The rougie, or finishing dye.*—The bouillon bath is emptied, and replaced with water for the *rougie*. When it is on the point of boiling, 5½ pounds of cochineal in fine powder are to be thrown in, and mixed with care; when the crust, which forms upon the surface, opens of itself in several places, 14 pounds of solution of tin (as above) are to be added. Should the liquor be likely to boil over the edges of the kettle, it must be refreshed with a little cold water. When the bath has become uniform, the cloth is to be put in, taking care to wince it briskly for two or three turns; then to boil it bodily for an hour, thrusting it under the liquor with a rod whenever it rises to the surface. It is lastly taken out, aired, washed at the river, and dried.

As no person has done more for the improvement of the scarlet dyes than Poërner, I shall here give his processes in detail.

Bouillon, or coloring.—For every pound of cloth or wool, take 14 drachms of cream of tartar. When the bath is boiling, and the tartar all dissolved, pour in successively 14 drachms of solution of tin (*Mordant* F, TIN), and let the whole boil together during a few minutes. Now introduce the cloth, and boil it for 2 hours; then take it out, and let it drain and cool.

Rougie, or dye.—For every pound of woollen stuff, take 2 drachms of cream of tartar. When the bath begins to boil, add 1 ounce of cochineal reduced to fine powder, stir the mixture well with a rod of willow or any white wood, and let it boil for a few minutes. Then pour in, by successive portions, 1 ounce of solution of tin (*Mordant* F), stirring continually with the rod. Lastly, dye as quickly as possible. The color will be a beautiful scarlet.

Second scarlet process of Poërner, the *bouillon* being the same as above given, and always estimated for 1 pound of cloth or wool. *Rougie.*—Take 1 ounce of cochineal in fine powder, and 2 ounces of solution of tin without tartar.

Third scarlet process of Poërner; the *bouillon* being as above. *Rougie* for a pound of cloth.—Take two drachms of cream of tartar, one ounce of cochineal, one ounce of solution of tin, and 2 ounces of sea salt; dye as in process 1. The salt helps the dye to penetrate into the cloth.

TABLES of the COMPOSITION of the BOUILLON and ROUGIE, by different Authors, for 100 pounds of Cloth or Wool.

Composition of the Bouillon.

Names of the Authors.	Starch.		Cream of Tartar.		Cochineal.		Solution of Tin.		Common Salt.	
	lb.	*oz.*	*lb.*	*oz.*	*lb.*	*dr.*	*lb.*	*oz.*	*lb.*	*oz.*
Berthollet - -	0	0	6	0	8	0	5	0	0	0
Hellot - -	0	0	12	8	18	6	12	8	0	0
Scheffer - -	9	6	9	6	12	4	9	6	0	0
Poërner - -	0	0	10	15	0	0	10	15	0	0

Composition of the Rougie.

Names of the Authors.	Starch.		Cream of Tartar.		Cochineal.		Solution of Tin.		Common Salt.	
	lb.	*oz.*	*lb.*	*oz.*	*lb.*	*oz.*	*lb.*	*oz.*	*lb.*	*oz.*
Berthollet - -	0	0	0	0	5	8	14	0	0	0
Hellot - -	3	2	0	0	7	4	12	8	0	0
Scheffer - -	3	2	3	2	5	7½	4	11	0	0
Poërner -	0	0	1	8	6	4	6	4	0	0
	0	0	0	0	6	4	12	8	0	0
	0	0	1	8	6	4	6	4	12	8

M. Lenormand states that he has made experiments of verification upon all the formulæ of the preceding tables, and declares his conviction that the finest tint may be obtained by taking the *bouillon* of Scheffer, and the *rougie* No. 4 of Poërner. The solution which produced the most brilliant red, is that made according to the process of mordant B (Tin.)

M. Robiquet has given the following prescription for making a *printing scarlet*, for well-whitened woollen cloth.

Boil a pound of pulverized cochineal in four pints of water down to 2 pints, and pass the decoction through a sieve. Repeat the boiling three times upon the residuum, mix the eight pints of decoction, thicken them properly with two pounds of starch, and boil into a paste. Let it cool down to 104° F., then add four ounces of the subjoined solution of tin, and two ounces of ordinary salt of tin (muriate.) When a ponçeau red is wanted, two ounces of pounded curcuma (turmeric) should be added.

The solution of tin above prescribed, is made by taking—one ounce of nitric acid, of specific gravity 36° B, = 1·33; one ounce of sal ammoniac; four ounces of grain tin. The tin is to be divided into eight portions, and one of them is to be put into the acid mixture every quarter of an hour.

A solution of chlorate of potassa (chloride ?) is said to beautify scarlet cloth in a remarkable manner.

Bancroft proposed to supplant the nitro-muriatic acid, by a mixture of sulphuric and muriatic acids, for dissolving tin; but I do not find that he succeeded in persuading scarlet-dyers to adopt his plans. In fact, the proper base is, in my opinion, a mixture of the protoxyde and peroxyde of tin; and this cannot be obtained by acting upon the metal with the murio-sulphuric acid. He also prescribed the extensive use of the quercitron yellow to change the natural crimson of the cochineal into scarlet, thereby economizing the quantity of this expensive dye-stuff. See Lac Dye.

SCHEELE'S GREEN is a pulverulent arsenite of copper, which may be prepared as follows:—Form, first, an arsenite of potassa, by adding gradually 11 ounces of arsenious acid to 2 pounds of carbonate of potassa, dissolved in 10 pounds of boiling water; next, dissolve 2 pounds of crystallized sulphate of copper in 30 pounds of water; filter each solution, then pour the first progressively into the second, as long as it produces a rich grass-green precipitate. This being thrown upon a filter-cloth, and edulcorated with warm water, will afford 1 pound 6 ounces of this beautiful pigment. It consists of, oxyde of copper 28·51, and of arsenious acid 71·46. This green is applied by an analogous double decomposition to cloth. See Calico-printing.

SCHWEINFURTH GREEN is a more beautiful and velvety pigment than the preceding, which was discovered in 1814, by MM. Rusz and Sattler, at Schweinfurth, and remained for many years a profitable secret in their hands. M. Liebig having made its composition known, in 1822, it has been since prepared in a great many color-works. Braconnot published, about the same time, another process for manufacturing the same pigment. Its preparation is very simple; but its formation is accompanied with some interesting circumstances. On mixing equal parts of acetate of copper and arsenious acid, each in a boiling concentrated solution, a bulky olive-green precipitate is immediately produced; while much acetic acid is set free. The powder thus obtained, appears to be a compound of arsenious acid and oxyde of copper, in a peculiar state; since when decomposed by sulphuric acid, no acetic odor is exhaled. Its color is not changed by drying, by exposure to air, or by being heated in water. But, if it be boiled in the acidulous liquor from which it was precipitated, it soon changes its color, as well as its state of aggregation, and forms a new deposite in the form of a dense granular beautiful green powder. As fine a color is produced by ebullition during five or six minutes, as is obtained at the end of several hours by mixing the two boiling solutions, and allowing the whole to cool together. In the latter case, the precipitate, which is slight and flocky at first, becomes denser by degrees; it next betrays green spots, which progressively increase, till the mass grows altogether of a crystalline constitution, and of a still more beautiful tint than if formed by ebullition.

When cold water is added to the mixed solutions, immediately after the precipitate takes place, the development of the color is retarded, with the effect of making it much finer. The best mode of procedure, is to add to the blended solutions, their own bulk of cold water, and to fill a globe up to the neck with the mixture, in order to prevent the formation of any such pellicle on the surface as might, by falling to the bottom, excite premature crystallization. Thus the reaction continues during two or three days with the happiest effect. The difference of tint produced by these variations, arises merely from the different sizes of the crystalline particles; for when the several powders are levigated upon a porphyry slab to the same degree, they have the same shade. Schweinfurth green, according to M. Ehrmann's researches, in the 31st *Bulletin de la Société Industrielle de Mulhausen*, consists of, oxyde of copper 31·666, arsenious acid 58·699, acetic acid 10·294. Kastner has given the following prescription for making this pigment: — For 8 parts of arsenious acid, take from 9 to 10 of verdigris; diffuse the latter through water at 120° F., and pass the pap through a sieve; then mix it with the arsenical solution, and set the mixture aside, till the reaction of the ingredients shall produce the wished-for shade of color. If a yellowish tint be desired, more arsenic must be used. By digesting Scheele's green in acetic acid, a variety of Schweinfurth green may be obtained.

Both of the above colors are rank poisons. The first was detected a few years ago, as the coloring-matter of some Parisian *bonbons*, by the *conseil de salubrité;* since which the confectioners were prohibited from using it, by the French government.

SCOURING, *or renovating articles of dress.* This art has been much more studied by Frenchmen, who wear the same coats for two or three years, than by Englishmen, who generally cast them off after so many months. The workmen who remove greasy stains from dress, are called, in France, *teinturiers-degraisseurs*, because they are often obliged to combine dyeing with scouring operations. The art of cleansing clothes being founded upon the knowledge of solvents, the practitioner of it should, as we shall presently illustrate by examples, be acquainted with the laws of chemical affinity.

Among the spots which alter the colors fixed upon stuffs, some are caused by a substance which may be described as *simple*, in common language; and others by a substance which results from the combination of two or more bodies, that may act separately or together upon the stuff, and which may therefore be called *compound.*

Simple stains.— Oils and fats are the substances which form the greater part of simple stains. They give a deep shade to the ground of the cloth; they continue to spread for several days; they attract the dust, and retain it so strongly, that it is not removeable by the brush; and they eventually render the stain lighter colored upon a dark ground, and of a disagreeable gray tint upon a pale or light ground.

The general principle of cleansing all spots, consists in applying to them a substance which shall have a stronger affinity for the matter composing them, than this has for the cloth, and which shall render them soluble in some liquid menstruum, such as water, spirits, naptha, oil of turpentine, &c. See BLEACHING.

Alkalis would seem to be proper in this point of view, as they are the most powerful solvents of grease; but they act too strongly upon silk and wool, as well as change too powerfully the colors of dyed stuffs, to be safely applicable in removing stains. The best substances for this purpose are—1. Soap. 2. Chalk, fuller's earth, soap-stone or steatite (called in this country French chalk). These should be merely diffused through a little water into a thin paste, spread upon the stain, and allowed to dry. The spot requires now to be merely brushed. 3. Ox-gall and yolk of egg have the property of dissolving fatty bodies without affecting perceptibly the texture or colors of cloth, and may therefore be employed with advantage. The ox-gall should be purified, to prevent its greenish tint from degrading the brilliancy of dyed stuffs, or the purity of whites. Thus prepared (see GALL), it is the most precious of all substances known for removing these kinds of stains. 4. The volatile oil of turpentine will take out only recent stains; for which purpose it ought to be previously purified by distillation over quicklime. Wax, rosin, turpentine, pitch, and all resinous bodies in general, form stains of greater or less adhesion, which may be dissolved out by pure alcohol. The juices of fruits, and the colored juices of all vegetables in general, deposite upon clothes marks in their peculiar hues. Stains of wine, mulberries, black currants, morellos, liquors, and weld, yield only to soaping with the hand, followed by fumigation with sulphurous acid; but the latter process is inadmissible with certain colored stuffs. Iron mould or rust stains may be taken out almost instantaneously with a strong solution of oxalic acid. If the stain is recent, cream of tartar will remove it.

Compound spots. — That mixture of rust of iron and grease called *cambouis* by the French, is an example of this kind, and requires two distinct operations; first, the removal of the grease, and then of the rust, by the means above indicated.

Mud, especially that of cities, is a compound of vegetable remains, and of ferruginous matter in a state of black oxyde. Washing with pure water, followed if necessary with soaping, will take away the vegetable juices; and then the iron may be removed with cream of tartar, which itself must, however, be well washed out. Ink stains, when recent, may be taken out by washing, first with pure water, next with soapy water, and lastly with lemon juice; but if old, they must be treated with oxalic acid. Stains occasioned by smoke, or by sauces browned in a frying-pan, may be supposed to consist of a mixture of pitch, black oxyde of iron, empyreumatic oil, and some saline matters dissolved in pyroligneous acid. In this case several reagents must be employed to remove the stains. Water and soap dissolve perfectly well the vegetable matters, the salts, the pyroligneous acid, and even the empyreumatic oils in a great measure; the essence of turpentine will remove the rest of the oils and all the pitchy matter; then oxalic acid may be used to discharge the iron. Coffee stains require a washing with water, with a careful soaping, at the temperature of 120° F., followed by sulphuration. The two latter processes may be repeated twice or thrice. Chocolate stains may be removed by the same means, and more easily.

As to those stains which change the color of the stuff, they must be corrected by appropriate chemical reagents or dyes. When black or brown cloth is reddened by an acid, the stain is best counteracted by the application of water of ammonia. If delicate silk colors are injured by soapy or alkaline matters, the stains must be treated with colorless vinegar of moderate force. An earthy compound for removing grease spots is made as follows: — Take fuller's earth, free it from all gritty matter by elutriation with water; mix with half a pound of the earth so prepared, half a pound of soda, as much soap, and eight yolks of eggs well beat up with half a pound of purified ox-gall. The whole must be carefully triturated upon a porphyry slab; the soda with the soap in the same manner as colors are ground, mixing in gradually the eggs and the ox-gall previously beat together. Incorporate next the soft earth by slow degrees, till a uniform thick paste be formed, which should be made into balls or cakes of a convenient size, and laid out to dry. A little of this detergent being scraped off with a knife, made into a paste with water, and applied to the stain, will remove it. Purified ox-gall is to be diffused through its own bulk of water, applied to the spots, rubbed well into them with the hands till they disappear, after which the stuff is to be washed with soft water. It is the best substance for removing stains on woollen clothes.

The redistilled oil of turpentine may also be rubbed upon the dry clothes with a sponge or a tuft of cotton till the spot disappear; but it must be immediately afterwards covered with some plastic clay reduced to powder. Without this precaution, a cloud would be formed round the stain, as large as the part moistened with the turpentine.

Oxalic acid may be applied in powder upon the spot previously moistened with water, well rubbed on, and then washed off with pure water.

Sulphurous acid is best generated at the moment of using it. If the clothes be much stained, they should be suspended in an ordinary fumigating chamber. For trifling stains, the sulphur may be burned under the wide end of a small card or paper funnel, whose upper orifice is applied near the cloth.

Manipulations of the scourer. — These consist, first, in washing the clothes in clear soft water, or in soap-water. The cloth must be next stretched on a sloping board, and rubbed with the appropriate reagent as above described, either by a sponge or a small hard brush. The application of a redhot iron a little way above a moistened spot often volatilizes the greasy matter out of it. Stains of pitch, varnish, or oil paint, which have become dry, must first be softened with a little fresh butter or lard, and then treated with the powder of the scouring ball. When the gloss has been taken from silk, it may be restored by applying the filtered mucilage of gum tragacanth; stretching it upon a frame to dry. Ribands are glossed with isinglass. Lemon juice is used to brighten scarlet spots, after they have been cleaned.

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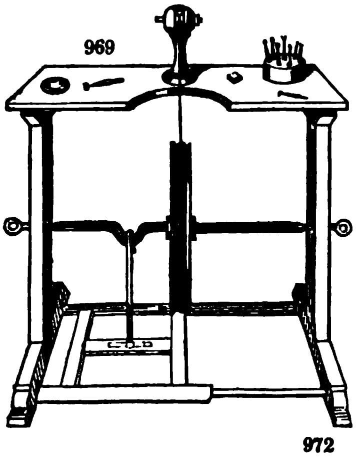

SEAL ENGRAVING. The art of *engraving gems* is one of extreme nicety. The stone having received its desired form from the lapidary, the engraver fixes it by cement to the end of a wooden handle, and then draws the outline of his subject, with a brass needle or a diamond, upon its smooth surface.

Fig. 969 represents the whole of the seal engraver's lathe. It consists of a table on which is fixed the mill, a small horizontal

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cylinder of steel; into one of whose extremities the tool is inserted, and which is made to revolve by the usual fly-wheel, driven by a treddle. The tools that may be fitted to the mill-cylinder, are the following; *fig.* 970 a hollow cylinder, for describing circles, and for boring; *fig.* 971 a knobbed tool, or rod terminated by a small ball; *fig.* 972 a stem terminated with a cutting disc, whose edge may be either rounded, square, or sharp; being in the last case called a saw.

Having fixed the tool best adapted to his style of work in the mill, the artist applies to its cutting point, or edge, some diamond-powder, mixed up with olive oil; and turning the wheel, he holds the stone against the tool, so as to produce the wished-for delineation and erosion. A similar apparatus is used for engraving on glass.

In order to give the highest degree of polish to the engraving, tools of boxwood, pewter, or copper, bedaubed with moistened tripoli or rotten-stone, and lastly, a brush, are fastened to the mill. These are worked like the above steel instruments. Modern engravings on precious stones have not in general the same fine polish as the ancient. The article Gems, in Rees' Cyclopædia, contains a variety of valuable information on this subject, equally interesting to the artist and the scholar.

SEALING-WAX. (*Cire à cacheter*, Fr.; *Siegellack*, Germ.) The Hindoos from time immemorial have possessed the resin lac, and were long accustomed to use it for sealing manuscripts before it was known in Europe. It was first imported from the East into Venice, and then into Spain; in which country sealing-wax became the object of a considerable commerce, under the name of Spanish wax.

If shellac be compounded into sealing-wax, immediately after it has been separated by fusion from the palest qualities of stick or seed lac, it then forms a better and less brittle article, than when the shellac is fused a second time. Hence sealing-wax, rightly prepared in the East Indies, deserves a preference over what can be made in other countries, where the lac is not indigenous. Shellac can be restored in some degree, however, to a plastic and tenacious state by melting it with a very small portion of turpentine. The palest shellac is to be selected for bright-colored sealing-wax, the dark kind being reserved for black.

The following prescription may be followed for making red sealing-wax:—Take 4 ounces of shellac, 1 ounce of Venice turpentine (some say 1½ ounces), and 3 ounces of vermilion. Melt the lac in a copper pan suspended over a clear charcoal fire, then pour the turpentine slowly into it, and soon afterwards add the vermilion, stirring briskly all the time of the mixture with a rod in either hand. In forming the round sticks of sealing-wax, a certain portion of the mass should be weighed while it is ductile, divided into the desired number of pieces, and then rolled out upon a warm marble slab, by means of a smooth wooden block, like that used by apothecaries for rolling a mass of pills. The oval sticks of sealing-wax are cast in moulds, with the above compound in a state of fusion. The marks of the lines of junction of the mould-box may be afterwards removed by holding the sticks over a clear fire, or passing them over a blue gas-flame. Marbled sealing-wax is made by mixing two, three, or more colored kinds of it, while they are in a semi-fluid state. From the viscidity of the several masses, their incorporation is left incomplete, so as to produce the appearance of marbling. Gold sealing-wax is made simply by stirring gold-colored mica spangles into the melted resins. Wax may be scented by introducing a little essential oil, essence of musk, or other perfume. If 1 part of balsam of Peru be melted along with 99 parts of the sealing-wax composition, an agreeable fragrance will be exhaled in the act of sealing with it. Either lamp black or ivory black serves for the coloring-matter of black wax. Sealing-wax is often adulterated with rosin; in which case it runs into thin drops at the flame of a candle.

SEA WATER, is composed as follows, according to the author of the article *Salines*, in the *Dictionnaire Technologique*:—Chloride of sodium, 2·50; chloride of magnesium, 0·35; sulphate of magnesia, 0·58; carbonates of lime and magnesia, 0·02; sulphate of lime, 0·01; water, 96·54, in 100 parts. See Salt, Sea.

SEGGAR, or SAGGER, is the cylindric case, of fire-clay, in which fine stoneware is enclosed while being baked in the kiln.

SELENIUM, from Σελήνη, the moon, is a metalloid principle, discovered by Berzelius, in 1817. It occurs sparingly in combination with several metals, as lead, cobalt, copper, and quicksilver, in the Harz, at Tilkerode; with copper and silver (*Eukairite*) in Sweden, with tellurium and bismuth in Norway, with tellurium and gold in Siebenbürgen, in several copper and iron pyrites, and with sulphur in the volcanic products of the Lipari Islands. Selenium has been found likewise in a red sediment which forms upon the bottoms of the lead chambers in which oil of vitriol has been made from peculiar pyrites, or pyritous sulphur. The extraction of selenium from that deposite is a very complex process.

Selenium, after being fused and slowly cooled, appears of a bluish-gray color, with a glistening surface; but it is reddish brown, and of metallic lustre when quickly cooled.

It is brittle, not very nard, and has little tendency to assume the crystalline state. Selenium is dark-red in powder, and transparent, with a ruby cast, in thin scales. Its specific gravity is 4·30. It softens at the temperature of 176° F., is of a pasty consistence at 212°, becomes liquid at a somewhat higher heat, forming in close vessels dark-yellow vapors, which condense into black drops; but in the air, the fumes have a cinnabar-red color.

This singular substance, apparently intermediate in its constitution between sulphur and metals, has not hitherto been applied to any use in the arts.

SELTZER WATER. See Soda-water, and Waters, Mineral.

SEPIA, is a pigment prepared from a black juice secreted by certain glands of the cuttle-fish, which the animal ejects to darken the water when it is pursued. One part of it is capable of making 1000 parts of water nearly opaque. All the varieties of this mollusca secrete the same juice; but the *Sepia officinalis*, the *Sepia ioligo*, and the *Sepia tunicata*, are chiefly sought after for making the pigment. The first, which occurs abundantly in the Mediterranean, affords most color; the sac containing it being extracted, the juice is to be dried as quickly as possible, because it runs rapidly into putrefaction. Though insoluble in water, it is extremely diffusible through it, and is very slowly deposited. Caustic alkalis dissolve the sepia, and turn it brown; but in proportion as the alkali becomes carbonated by exposure to air, the sepia falls to the bottom of the vessel. Chlorine blanches it slowly. It consists of carbon in an extremely divided state, along with albumine, gelatine, and phosphate of lime.

The dried native sepia is prepared for the painter, by first triturating it with a little caustic ley, then adding more ley, boiling the liquid for half an hour, filtering, next saturating the alkali with an acid, separating the precipitate, washing it with water, and finally drying it with a gentle heat. The pigment is of a brown color, and a fine grain.

SEPTARIA, called anciently *ludus Helmontii*, (the *quoits* of Van Helmont, from their form,) are lenticular concretions of clay ironstone, intersected by veins of calc-spar, which, when calcined, and ground to powder, form an excellent hydraulic cement. See Mortar, Hydraulic.

SERPENTINE, is a mineral of the magnesian family, of a green color; it is scratched by calcareous spar, is sectile, tough, and therefore easily cut into ornamental forms. It occurs in Unst and Fetlar, in Shetland; at Portsoy, in Banffshire; in Cornwall; and the Isle of Holyhead. The floors of bakers' ovens are advantageously laid with slabs of serpentine.

SHAFT, in mining, signifies a perpendicular or slightly inclined pit.

SHAGREEN. (*Chagrin*, Fr. and Germ.) The true oriental shagreen is essentially different from all modifications of leather and parchment. It approaches the latter somewhat, indeed, in its nature, since it consists of a dried skin, not combined with any tanning or foreign matter whatever. Its distinguishing characteristic is having the grain or hair side covered over with small rough round specks or granulations.

It is prepared from the skins of horses, wild asses, and camels; of strips cut along the chine, from the neck towards the tail, apparently because this stronger and thicker portion of the skin is best adapted to the operations about to be described. These fillets are to be steeped in water till the epidermis becomes loose, and the hairs easily come away by the roots; after which they are to be stretched upon a board, and dressed with the currier's fleshing-knife. They must be kept continually moist, and extended by cords attached to their edges, with the flesh side uppermost upon the board. Each strip now resembles a wet bladder, and is to be stretched in an open square wooden frame by means of strings tied to its edges, till it be as smooth and tense as a drum-head. For this purpose it must be moistened and extended from time to time in the frame.

The grain or hair side of the moist strip of skin must next be sprinkled over with a kind of seeds called *Allabuta*, which are to be forced into its surface either by tramping with the feet, or with a simple press, a piece of felt or other thick stuff being laid upon the seeds. These seeds belong probably to the *Chenapodium album*. They are lenticular, hard, of a shining black color, farinaceous within, about the size of poppy seed, and are sometimes used to represent the eyes in wax figures.

The skin is exposed to dry in the shade, with the seeds indented into its surface; after which it is freed from them by shaking it, and beating upon its other side with a stick. The outside will be then horny, and pitted with small hollows corresponding to the shape and number of the seeds.

In order to make the next process intelligible, we must advert to another analogous and well-known operation. When we make impressions in fine-grained dry wood with steel punches or letters of any kind, then plane away the wood till we come to the level of the bottom of these impressions, afterwards steep the wood in water, the condensed or punched points will swell above the surface, and place the letters in relief. Snuff-boxes have sometimes been marked with prominent figures in this way. Now shagreen is treated in a similar manner.

The strip of skin is stretched in an inclined plane, with its upper edge attached to hooks, and its under one loaded with weights, in which position it is thinned off with a proper semi-lunar knife, but not so much as to touch the bottom of the seed-pits or depressions. By maceration in water, the skin is then made to swell, and the pits become prominent over the surface which had been shaved. The swelling is completed by steeping the strips in a warm solution of soda, after which they are cleansed by the action of salt brine, and then dyed.

In the East the following processes are pursued. Entirely white shagreen is obtained by imbuing the skin with a solution of alum, covering it with the dough made with Turkey wheat, and after a time washing this away with a solution of alum. The strips are now rubbed with grease or suet, to diminish their rigidity, then worked carefully in hot water, curried with a blunt knife, and afterwards dried. They are died red with decoction of cochineal or kermes, and green with fine copper filings and sal ammoniac, the solution of this salt being first applied, then the filings being strewed upon the skin, which must be rolled up and loaded with weights for some time; blue is given with indigo, quicklime, soda, and honey; and black, with galls and copperas.

SHALE, or SLATE CLAY, is an important stratiform member of the coal-measures. See PITCOAL.

SHAMOY LEATHER. See LEATHER.

SHEATHING OF SHIPS. For this purpose many different metals and metallic alloys have been lately proposed. From a train of researches which I made for an eminent copper company, a few years ago, upon various specimens of sheathing which had been exposed upon ships during many voyages, it appeared that copper containing a minute but definite proportion of tin, was by far the most durable.

SHELLAC. See LAC, and SEALING-WAX.

SIENITE is a granular aggregated compound rock, consisting of feldspar and hornblende, sometimes mixed with a little quartz and mica. The hornblende is the characteristic ingredient, and serves to distinguish sienite from granite, with which it has been sometimes confounded; though the feldspar, which is generally red, is the more abundant constituent. The Egyptian sienite, containing but little hornblende, with a good deal of quartz and mica, approaches most nearly to granite. It is equally metalliferous with porphyry; in the island of Cyprus, it is rich in copper; and in Hungary, it contains many valuable gold and silver mines.

Sienite forms a considerable part of the Criffle, a hill in Galloway. It takes its name from the city of Syene, in the Thebaid, near the cataracts of the Nile, where this rock abounds. It is an excellent building-stone, and was imported in large quantities from Egypt by the Romans, for the architectural and statuary decorations of their capital.

SILICA and SILICON. (*Silice, silicium*, Fr.; *Kieselerde, kiesel*, Germ.) Silica was till lately ranked among the earths proper; but since the researches of Davy and Berzelius, it has been transferred to the chemical class of acids. It constitutes the principal portion of most of the hard stones and minerals which compose the crust of the globe; occurring nearly pure in rock crystal, quartz, agate, calcedony, flint, &c. Silica or silicic acid may be obtained perfectly pure, and also in the finest state of comminution, by taking the precipitate formed by passing silicated fluoric gas through water, filtering, washing, and igniting it, to expel the last traces of the fluoride of silicon. The powder thus obtained is so light as to be blown away with the least breath of air. Silica may be more conveniently procured, however, by fusing ground flint with four times its weight of a mixture, in equal parts, of dry carbonate of potassa and carbonate of soda, in a platinum or silver crucible. The alkaline carbonates should be first fused, and the flint powder sprinkled into the liquid, as long as it dissolves with effervescence. The mass is to be then allowed to cool, dissolved in dilute muriatic acid; the solution is to be filtered, and evaporated to dryness; the dry crust is to be pulverized, digested for two hours with a little muriatic acid, to remove any iron and alumina that may be present, next washed with hot water, drained, dried, and ignited.

The above silicate of potassa and soda is the compound called soluble glass, which applied in solution to the surface of wood, calico, paper, &c., renders them unsusceptible of taking fire on the contact of an ignited body.

Silica, as thus prepared, is a white powder, rough to the touch, gritty between the teeth, absolutely insoluble in water, acids, and most liquids. Its specific gravity is 2·66. It cannot be fused by the most intense heat of our furnaces, but at the flame of the oxy-hydrogen blowpipe it melts into a limpid colorless glass. By peculiar chemical methods, an aqueous solution of it may be made artificially, similar to what nature presents us with in many thermal springs, as in those of Reikum and of Geyser in Iceland, and of most mineral waters, in minute quantity. There is no acid except the fluoric which can directly dissolve dry or calcined silica. Silica is composed of 48·04 silicon, and 51·96 oxygen.

SILICATES are compounds of silicic acid (silica), with the bases alumina, lime, magnesia, potassa, soda, &c. They constitute the greater number by far of the hard minerals which incrust the terrestrial globe. Thus cyanite is a subsilicate of alumina; feldspar and leucite, are silicates of alumina and potassa; albite and analcime, are silicates of alumina and soda; stilbite, prehnite, mesolite, labradorite, tourmaline, mica, &c., are silicates of alumina and lime; chrysolite, steatite, serpentine, and meerschaum, are silicates of magnesia; augite and hornblende, are silicates of lime and magnesia, &c.

SILICON, called also silicium, may be obtained by burning potassium in silicated fluoric gas. The product of the combustion is a brown cinder, which, on being thrown into water, disengages hydrogen with violence, and lets fall a dark liver-brown powder, upon which water exercises no action. This matter is silicon mixed with a salt of difficult solution, which is composed of fluorine, potassium, and silicon. This salt may, however, be removed by a great deal of washing. The further details of this curious subject will be given in my forthcoming system of chemistry.

SILK MANUFACTURE. (*Fabrique de soie*, Fr.; *Seidenfabrik*, Germ.) This may be divided into two branches; 1. the production of raw silk; 2. its filature and preparation in the mill, for the purposes of the weaver and other textile artisans. The threads, as spun by the silkworm, and wound up in its cocoon, are all twins, in consequence of the twin orifice in the nose of the insect through which they are projected. These two threads are laid parallel to each other, and are glued more or less evenly together by a kind of glossy varnish, which also envelopes them, constituting nearly 25 per cent. of their weight. Each ultimate filament measures about $\frac{1}{2000}$ of an inch in average fine silk, and the pair measures of course fully $\frac{1}{1000}$ of an inch. In the raw silk, as imported from Italy, France, China, &c., several of these twin filaments are slightly twisted and agglutinated to form one thread, called a single.

The specific gravity of silk is 1·300, water being 1·000. It is by far the most tenacious or the strongest of all textile fibres, a thread of it of a certain diameter being nearly three times stronger than a thread of flax, and twice stronger than hemp. Some varieties of silk are perfectly white, but the general color in the native state is a golden yellow.

The production of silk was unknown in Europe till the sixth century, when two monks, who brought some eggs of the silkworm from China or India to Constantinople, were encouraged to breed the insect, and cultivate its cocoons, by the Emperor Justinian. Several silk manufactures were in consequence established in Athens, Thebes, and Corinth, not only for rearing the worm upon mulberry-leaves, but for unwinding its cocoons, for twisting their filaments into stronger threads, and weaving these into robes. The Venetians having then and long afterwards intimate commercial relations with the Greek empire, supplied the whole of western Europe with silk goods, and derived great riches from the trade.

About 1130, Roger II., king of Sicily, set up a silk manufacture at Palermo, and another in Calabria, conducted by artisans whom he had seized and carried off as prisoners of war in his expedition to the Holy Land. From these countries, the silk industry soon spread throughout Italy. It seems to have been introduced into Spain at a very early period, by the Moors, particularly in Murcia, Cordova, and Granada. The last town, indeed, possessed a flourishing silk trade when it was taken by Ferdinand in the 15th century. The French having been supplied with workmen from Milan, commenced, in 1521, the silk manufacture; but it was not till 1564 that they began successfully to produce the silk itself, when Traucat, a working gardener at Nismes, formed the first nursery of white mulberry-trees, and with such success, that in a few years he was enabled to propagate them over many of the southern provinces of France. Prior to this time, some French noblemen, on their return from the conquest of Naples, had introduced a few silkworms with the mulberry into Dauphiny; but the business had not prospered in their hands. The mulberry plantations were greatly encouraged by Henry IV.; and since then they have been the source of most beneficial employment to the French people. James I. was most solicitous to introduce the breeding of silkworms into England, and in a speech from the throne he earnestly recommended his subjects to plant mulberry-trees; but he totally failed in the project. This country does not seem to be well adapted for this species of husbandry, on account of the great prevalence of blighting east winds during the months of April and May, when the worms require a plentiful supply of mulberry-leaves. The manufacture of silk goods, however, made great progress during that king's peaceful and pompous reign. In 1629 it had become so considerable in London, that the silk-throwsters of the city and suburbs were formed into a public corporation. So early as 1661, they employed 40,000 persons. The revocation of the edict of Nantes, in 1685, contributed in a remarkable manner to the increase of the English silk trade, by the influx of a large colony of skilful French weavers, who settled in Spitalfields. The great silk-throwing mill mounted at Derby, in 1719, also served to promote the extension of this branch of manufacture; for some afterwards, in the year 1730, the English silk goods bore a higher price in Italy than those made by the Italians, according to the testimony of Keysler.

Till the year 1826, however, our silk manufactures in general labored under very grievous fiscal burdens. Foreign organzine, or twisted raw silk, paid an import duty of 14*s.* 7½*d.* per pound; Raw Bengal silk, 4*s.*; and that from other places, 5*s.* 7½*d.* Mr. Huskisson introduced a bill at that time, reducing the duty on organzine to 5*s.*, and the duty on other raw silk to 3*d.* per pound. The total prohibition of the import of French manufactured silks, which gave rise to so much contraband trade, was also converted into a duty of 30 per cent. *ad valorem.* During the reign of the prohibitory system, when our silk weavers had no variety of patterns to imitate, and no adequate stimulus to excel, on account of the monopoly which they possessed in the home market, the inferiority of their productions was a subject of constant pride and congratulation among the Lyonnais; and accordingly the English could not stand their competition any where. At that time, the disadvantage on English silk goods, compared to French, was estimated in foreign markets at 40 per cent.; of late years it certainly does not exceed 20, notwithstanding the many peculiar facilities which France enjoys for this her favorite staple.

The silkworm, called by entomologists *Phalæna bombyx mori*, is, like its kindred species, subject to four metamorphoses. The egg, fostered by the genial warmth of spring, sends forth a caterpillar, which, in its progressive enlargement, casts its skin either three or four times, according to the variety of the insect. Having acquired its full size in the course of 25 or 30 days, and ceasing to eat during the remainder of its life, it begins to discharge a viscid secretion, in the form of pulpy twin filaments, from its nose, which harden in the air. These threads are instinctively coiled into an ovoid nest round itself, called a cocoon, which serves as a defence against living enemies and changes of temperature. Here it soon changes into the chrysalis or nymph state, in which it lies swaddled, as it were, for about 15 or 20 days. Then it bursts its cerements, and comes forth furnished with appropriate wings, antennæ, and feet, for living in its new element, the atmosphere. The male and the female moths couple together at this time, and terminate their union by a speedy death, their whole existence being limited to two months. The cocoons are completely formed in the course of three or four days; the finest being reserved as seed worms. From these cocoons, after an interval of 18 or 20 days, the moth makes its appearance, perforating its tomb by knocking with its head against one end of the cocoon, after softening it with saliva, and thus rendering the filaments more easily torn asunder by its claws. Such moths or aurelias are collected and placed upon a piece of soft cloth, where they couple and lay their eggs.

The eggs, or grains, as they are usually termed, are enveloped in a liquid which causes them to adhere to the piece of cloth or paper on which the female lays them. From this glue they are readily freed, by dipping them in cold water, and wiping them dry. They are best preserved in the *ovum* state at a temperature of about 55° F. If the heat of spring advances rapidly in April, it must not be suffered to act on the eggs, otherwise it might hatch the caterpillars long before the mulberry has sent forth its leaves to nourish them. Another reason for keeping back their incubation is, that they may be hatched together in large broods, and not by small numbers in succession. The eggs are made up into small packets, of an ounce, or somewhat more, which in the south of France are generally attached to the girdles of the women during the day, and placed under their pillows at night. They are, of course, carefully examined from time to time. In large establishments, they are placed in an appropriate stove-room, where they are exposed to a temperature gradually increased till it reaches the 86th degree of Fahrenheit's scale, which term it must not exceed. Aided by this heat, nature completes her mysterious work of incubation in eight or ten days. The teeming eggs are now covered with a sheet of paper pierced with numerous holes, about one twelfth of an inch in diameter. Through these apertures the new-hatched worms creep upwards instinctively, to get at the tender mulberry leaves strewed over the paper.

The nursery where the worms are reared is called by the French a *magnanière;* it ought to be a well-aired chamber, free from damp, excess of cold or heat, rats, and other vermin. It should be ventilated occasionally, to purify the atmosphere from the noisome emanations produced by the excrements of the caterpillars and the decayed leaves. The scaffolding of the wicker-work shelves should be substantial; and they should be from 15 to 18 inches apart. A separate small apartment should be allotted to the sickly worms. Immediately before each moulting, the appetite of the worms begins to flag; it ceases altogether at that period of cutaneous metamorphosis, but revives speedily after the skin is fairly cast, because the internal parts of the animal are thereby allowed freely to develop themselves. At the end of the second age, the worms are half an inch long; and then should be transferred from the small room in which they were first hatched, into the proper apartment where they are to be brought to maturity and set to spin their balls. On occasion of changing their abode, they must be well cleansed from the litter, laid upon beds of fresh leaves, and supplied with an abundance of food every six hours in succession. In shifting their bed, a piece of network being laid over the wicker plates, and covered with leaves, the worms will creep up over them; when they may be transferred in a body upon the net. The litter, as well as the sickly worms, may thus be readily removed, without handling a single healthy one. After the third age, they may be fed with entire leaves; because they are now exceedingly voracious, and must not be subsequently stinted in their diet. The exposure of chloride of lime, spread thin upon plates, to the air of the *magnanière*, has been found useful in counteracting the tendency which sometimes appears of an epidemic disease among the silkworms, from the fetid exhalations of the dead and dying.

When they have ceased to eat, either in the fourth or fifth age, agreeably to the variety of the *bombyx*, and when they display the spinning instinct by crawling up among the twigs of heath, &c., they are not long of beginning to construct their cocoons, by throwing the thread in different directions, so as to form the floss, filoselle, or outer open network, which constitutes the *bourre* or silk for carding and spinning.

The cocoons destined for filature, must not be allowed to remain for many days with the worms alive within them; for should the chrysalis have leisure to grow mature or come out, the filaments at one end would be cut through, and thus lose almost all their value. It is therefore necessary to extinguish the life of the animal by heat, which is done either by exposing the cocoons for a few days to sunshine, by placing them in a hot oven, or in the steam of boiling water. A heat of 202° F. is sufficient for effecting this purpose, and it may be best administered by plunging tin cases filled with the cocoons into water heated to that pitch.

80 pounds French (88 Eng.) of cocoons, are the average produce from one ounce of eggs, or 100 from one ounce and a quarter; but M. Folzer of Alsace obtained no less than 165 pounds. The silk obtained from a cocoon is from 750 to 1150 feet long. The varnish by which the coils are glued slightly together, is soluble in warm water.

The silk husbandry, as it may be called, is completed in France within six weeks from the end of April, and thus affords the most rapid of agricultural returns, requiring merely the advance of a little capital for the purchase of the leaf. In buying up cocoons, and in the filature, indeed, capital may be often laid out to great advantage. The most hazardous period in the process of breeding the worms, is at the third and fourth moulting; for upon the sixth day of the third age, and the seventh day of the fourth, they in general eat nothing at all. On the first day of the fourth age, the worms proceeding from one ounce of eggs will, according to Bonafons, consume upon an average twenty-three pounds and a quarter of mulberry leaves; on the first of the fifth age, they will consume forty-two pounds; and on the sixth day of the same age, they acquire their maximum voracity, devouring no less than 223 pounds. From this date their appetite continually decreases, till on the tenth day of this age they consume only fifty-six pounds. The space which they occupy upon the wicker tables, being at their birth only nine feet square, becomes eventually 239 feet. In general, the more food they consume, the more silk will they produce.

A mulberry-tree is valued, in Provence, at from 6*d*. to 10*d*.; it is planted out of the nursery at four years of age; it is begun to be stripped in the fifth year, and affords an increasing crop of leaves till the twentieth. It yields from 1 cwt. to 30 cwts. of leaves, according to its magnitude and mode of cultivation. One ounce of silkworm eggs is worth in France about 2½ francs; it requires for its due development into cocoons about 15 cwts. of mulberry leaves, which cost upon an average 3 francs per cwt. in a favorable season. One ounce of eggs is calculated, as I have said, to produce from 80 to 100 pounds of cocoons, of the value of 1 fr. 52 centimes per pound, or 125 francs in whole. About 8 pounds of reeled raw silk, worth 18 francs a pound, are obtained from these 100 pounds of cocoons.

There are three denominations of raw silk; viz., organzine, *trame* (shute or tram), and floss. Organzine serves for the warp of the best silk stuffs, and is considerably twisted; tram is made usually from inferior silk, and is very slightly twisted, in order that it may spread more, and cover better in the weft; floss, or *bourre*, consists of the shorter broken silk, which is carded and spun like cotton. Organzine and trame may contain from 3 to 30 twin filaments of the worm; the former possesses a double twist, the component filaments being first twisted in one direction, and the compound thread in the opposite; the latter receives merely a slender single twist. Each twin filament gradually diminishes in thickness and strength, from the surface of the cocoon, where the animal begins its work in a state of vigor, to the centre, where it finishes it, in a state of debility and exhaustion; because it can receive no food from the moment of its beginning to spin by spouting forth its silky substance. The winder is attentive to this progressive attenuation, and introduces the commencement of some cocoons to compensate for the termination of others. The quality of raw silk depends, therefore, very much upon the skill and care bestowed upon its filature. The softest and purest water should be used in the cocoon kettle.

The quality of the raw silk is determined by first winding off 400 ells of it, equal to 475 metres, round a drum one ell in circumference, and then weighing that length. The weight is expressed in grains, 24 of which constitute one denier; 24 deniers constitute one ounce; and 16 ounces make one pound, *poids de marc.* This is the Lyons rule for valuing silk. The weight of a thread of raw silk 400 ells long, is two grains and a half, when five twin filaments have been reeled and associated together.

Raw silk is so absorbent of moisture, that it may be increased ten per cent. in weight by this means. This property has led to falsifications; which are detected by enclosing weighed portions of the suspected silk in a wire-cloth cage, and exposing it to a stove-heat of about 78° F. for 24 hours, with a current of air. The loss of weight which it thereby undergoes, demonstrates the amount of the fraud. There is an office in Lyons called the *Condition*, where this assay is made, and by the report of which the silk is bought and sold. The law in France requires, that all the silk tried by the *Condition* must be worked up into fabrics in that country.

In the Journal of the Asiatic Society of Bengal, for January, 1837, there are two very valuable papers upon silkworms; the first, upon those of Assam, by Mr. Thomas Hugon, stationed at Nowgong; the second by Dr. Helfer, upon those which are indigenous to India. Besides the *Bombyx mori*, the Doctor enumerates the following seven species, formerly unknown: — 1. The wild silkworm of the central provinces, a moth not larger than the *Bombyx mori.* 2. The Joree silkworm of Assam, *Bombyx religiosæ*, which spins a cocoon of a fine filament, with much lustre. It lives upon the pipul tree (*Ficus religiosa*), which abounds in India, and ought therefore to be turned to account in breeding this valuable moth. 3. *Saturnia silhetica*, which inhabits the cassia mountains in Silhet and Dacca, where its large cocoons are spun into silk. 4. A still larger *Saturnia*, one of the greatest moths in existence, measuring ten inches from the one end of the wing to the other; observed by Mr. Grant, in *Chirra punjee.* 5. *Saturnia paphia*, or the Tusseh silkworm, is the most common of the native species, and furnishes the cloth usually worn by Europeans in India. It has not hitherto been domesticated, but millions of its cocoons are annually collected in the jungles, and brought to the silk factories near Calcutta and Bhagelpur. It feeds most commonly on the hair-tree (*Zizyphus jujuba*), but it prefers the *Terminalia alata*, or Assam tree, and the *Bombax heptaphyllum.* It is called *Koutkuri mooga*, in Assam. 6. Another *Saturnia*, from the neighborhood of Comercolly. 7. *Saturnia assamensis*, with a cocoon of a yellow-brown color, different from all others, called *mooga*, in Assam; which, although it can be reared in houses, thrives best in the open air upon trees, of which seven different kinds afford it food. The *Mazankoory mooga*, which feeds on the Adakoory tree, produces a fine silk, which is nearly white, and fetches 50 per cent. more than the fawn-colored. The trees of the first year's growth produce by far the most valuable cocoons. The mooga which inhabits the soom-tree, is found principally in the forests of the plains, and in the villages. The tree grows to a large size, and yields three crops of leaves in the year. The silk is of a light fawn color, and ranks next in value to the Mazankoory. There are generally five breeds of mooga worms in the year; 1. in January and February; 2. in May and June; 3. in June and July; 4. in August and September; 5. in October and November; the first and last being the most valuable.

The Assamese select for breeding, such cocoons only as have been begun to be formed in the largest number on the same day, usually the second or third after the commencement; those which contain males being distinguishable by a more pointed end. They are put in a closed basket suspended from the roof; the moths, as they come forth, having room to move about, after a day, the females (known only by their large body) are taken out, and tied to small wisps of thatching-straw, selected always from over the hearth, its darkened color being thought more acceptable to the insect. If out of a batch, there should be but few males, the wisps with the females tied to them are exposed outside at night; and the males thrown away in the neighborhood find their way to them. These wisps are hung upon a string tied across the roof, to keep them from vermin. The eggs laid after the first three days are said to produce weak worms. The wisps are taken out morning and evening, and exposed to the sunshine, and in ten days after being laid, a few of them are hatched. The wisps being then hung up to the tree, the young worms find their way to the leaves. The ants, whose bite is fatal to the worm in its early stages, are destroyed by rubbing the trunk of the tree with molasses, and tying dead fish and toads to it, to attract these rapacious insects in large numbers, when they are destroyed with fire; a process which needs to be repeated several times. The ground under the trees is also well cleared, to render it easy to pick up and replace the worms which fall down. They are prevented from coming to the ground by tying fresh plantain-leaves round the trunk, over whose slippery surface they cannot crawl; and they are transferred from exhausted trees to fresh ones, on bamboo platters tied to long poles. The worms require to be constantly watched and protected from the depredations of both day and night birds, as well as rats and other vermin. During their moultings, they remain on the branches; but when about beginning to spin, they come down the trunk, and being stopped by the plantain-leaves, are there collected in baskets, which are afterwards put under bunches of dry leaves, suspended from the roof, into which the worms crawl, and form their cocoons—several being clustered together: this accident, due to the practice of crowding the worms together, which is most injudicious, rendering it impossible to wind off their silk in continuous threads, as in the filatures of Italy, France, and even Bengal. The silk is, therefore, spun like flax, instead of being unwound in single filaments. After four days the proper cocoons are selected for the next breed, and the rest are uncoiled. The total duration of a breed varies from 60 to 70 days; divided into the following periods:—

Four moultings, with one day's illness attending each	20
From fourth moulting to beginning of cocoon	10
In the cocoon 20, as a moth 6, hatching of eggs 10	36
	66

On being tapped with the finger, the body renders a hollow sound; the quality of which shows whether they have come down for want of leaves on the tree, or from their having ceased feeding.

As the chrysalis is not soon killed by exposure to the sun, the cocoons are put on stages, covered up with leaves, and exposed to the hot air from grass burned under them; they are next boiled for about an hour in a solution of the potash, made from incinerated rice-stalks; then taken out, and laid on cloth folded over them to keep them warm. The floss being removed by hand, they are then thrown into a basin of hot water to be unwound; which is done in a very rude and wasteful way.

The plantations for the mooga silkworm in Lower Assam, amount to 5000 acres, besides what the forests contain; and yield 1500 maunds of 84 lbs. each per annum. Upper Assam is more productive.

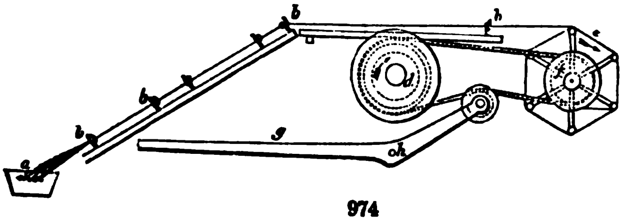
The cocoon of the *Koutkuri mooga* is of the size of a fowl's egg. It is a wild species, and affords filaments much valued for fishing-lines. See SILKWORM GUT.

8. The *Arrindy*, or *Eria* worm, and moth, is reared over a great part of Hindostan, but entirely within doors. It is fed principally on the *Hera*, or *Palma christi* leaves, and gives sometimes 12 broods of spun silk in the course of a year. It affords a fibre which looks rough at first; but when woven, becomes soft and silky, after repeated washings. The poorest people are clothed with stuff made of it, which is so durable as to descend from mother to daughter. The cocoons are put in a closed basket, and hung up in the house, out of reach of rats and insects. When the moths come forth, they are allowed to move about in the basket for twenty-four hours; after which the females are tied to long reeds or canes, twenty or twenty-five to each, and these are hung up in the house. The eggs that are laid the first three days, amounting to about 200, alone are kept; they are tied up in a cloth, and suspended to the roof till a few begin to hatch. These eggs are white, and of the size of turnip-seed. When a few of the worms are hatched, the cloths are put on small bamboo platters hung up in the house, in which they are fed with tender leaves. After the second moulting, they are removed to bunches of leaves suspended above the ground, beneath which a mat is laid to receive them when they fall. When they cease to feed, they are thrown into baskets full of dry leaves, among which they form their cocoons, two or three being often found joined together. Upon this injudicious practice I have already animadverted.

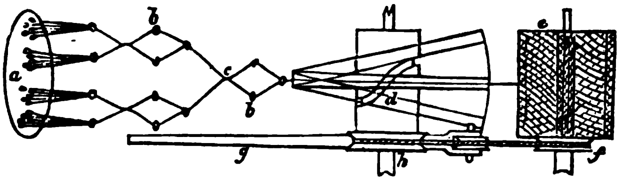
9. The *Saturnia trifenestrata* has a yellow cocoon of a remarkably silky lustre. It lives on the soom-tree in Assam, but seems not to be much used.

The mechanism of the silk filature, as lately improved in France, is very ingenious. *Figs.* 973 and 974 exhibit it in plan and longitudinal view. *a* is an oblong copper basin containing water heated by a stove or by steam. It is usually divided by transverse partitions into several compartments, containing 20 cocoons, of which there are 5 in one group, as shown in the figure. *b*, *b*, are wires with hooks or eyelets at their ends, through which the filaments run, apart, and are kept from ravelling. *c*, *c*, the points where the filaments cross and rub each other, on purpose to clean their surfaces. *d*, is a spiral groove, working upon a pin point, to give the traverse motion alternately to right and left, whereby the thread is spread evenly over the surface of the reel *e*. *f*, *f*, are the pulleys, which by means of cords transmit the rotatory movement of the cylinder *d*, to the reel *e*. *g*, is a friction lever or tumbler, for lightening or slackening the endless cord, in the act of starting or stopping the winding operation. Every apartment of a large filature contains usually a series of such reels as the above, all driven by one prime mover; each of which, however, may by means of the tumbling lever be stopped at

973



974



pleasure. The reeler is careful to remove any slight adhesions, by the application of a brush in the progress of her work.

The expense of reeling the excellent Cevennes silk is only 3 francs and 50 centimes per Alais pound; from 4 to 5 cocoons going to one thread. That pound is 92 hundredths of our avoirdupois pound. In Italy, the cost of reeling silk is much higher, being 7 Italian livres per pound, when 3 to 4 cocoons go to the formation of one thread; and 6 livres when there are from 4 to 5 cocoons. The first of these raw silks will have a *titre* of 20 to 24 deniers; the last, of 24 to 28. If 5 to 6 cocoons go to one thread, the titre will be from 26 to 32 deniers, according to the quality of the cocoons. The Italian livre is worth 7½*d.* English. The woman employed at the kettle receives one livre and five sous per day; and the girl who turns the reel, gets thirteen sous a day; both receiving board and lodging in addition. In June, July, and August, they work 16 hours a day, and then they wind a *rubo* or ten pounds weight of cocoons, which yield from 1-5th to 1-6th of silk, when the quality is good. The whole expenses amount to from 6 to 7 livres upon every ten pounds of cocoons; which is about 2*s.* 8*d.* per English pound of raw silk.

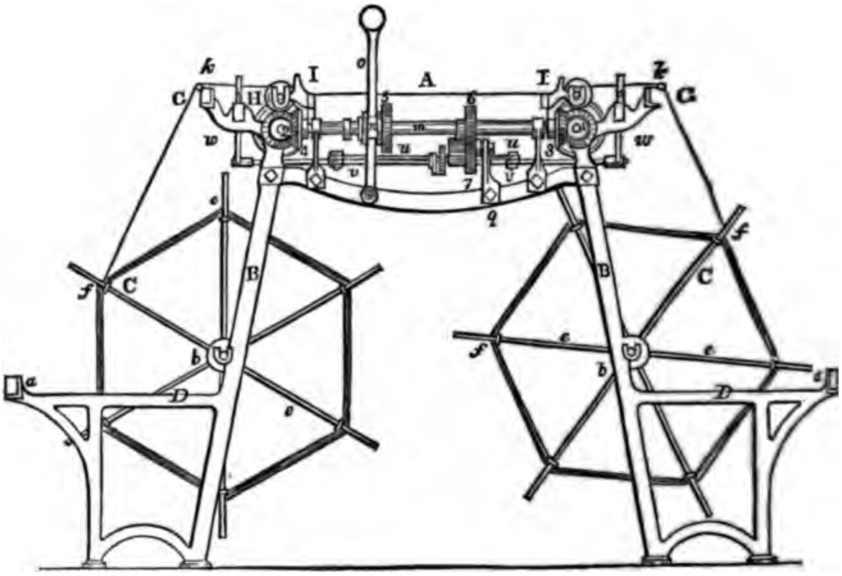
The raw silk, as imported into this country in hanks from the filatures, requires to be regularly wound upon bobbins, doubled, twisted, and reeled in our silk-mills. These processes are called *throwing* silk, and their proprietors are called silk *throwsters;* terms probably derived from the appearance of swinging or tossing which the silk threads exhibit during their rapid movements among the machinery of the mills.

A representation of a French mill for throwing silk, is given in the *Dictionnaire Technologique*, under the article *Moulinage de Soie.* But it is a most awkward, operose, and defective piece of machinery, quite unworthy of being presented to my readers. It was in Manchester that throwing-mills received the grand improvement upon the ancient Italian plan, which had been originally introduced into this country by Sir Thomas Lombe, and erected at Derby. That improvement is chiefly due to the eminent factory engineers, Messrs. Fairbairn and Lillie, who transferred to silk the elegant mechanism of the throstle, so well known in the cotton trade. Still, throughout the silk districts of France, the throwing mills are generally small, not many of them turning off more than 1000 pounds of organzine per annum, and not involving 5000*l.* of capital. The average price of throwing organzine in that country, where the throwster is not answerable for loss, is 7 francs; of throwing trame, from 4 fr. to 5 fr. (per kilogramme ?) Where the throwster is accountable for loss, the price is from 10 fr. to 11 fr. for organzine, and from 6 to 7 for trame. In Italy, throwing adds 3*s.* 9*d.* to the price of raw silk, upon an average. I should imagine, from the perfection and speed of the silk-throwing machinery in this country, as about to be described, that the cost of converting a pound of raw silk either into organzine or *trame* must be considerably under any of the above sums.

SILK-THROWING MILL.

The first process to which the silk is subjected, is winding the skeins, as imported, off upon bobbins. The mechanism which effects this winding off and on, is technically called the *engine*, or swift. The bobbins to which the silk is transferred, are wooden cylinders, of such thickness as may not injure the silk by sudden flexure, and which may also receive a great length of thread without having their diameter materially increased, or their surface velocity changed. *Fig.* 975 is an end view of the silk throwing machine, or *engine*, in which the two large hexagonal reels, called swifts, are seen in section, as well as the table between them, to which the bobbins and impelling mechanism are attached. The skeins are put upon these reels, from which the silk is gradually unwound by the traction of the revolving bobbins. One principal object of attention, is to distribute the thread over the length of the bobbin-cylinder in a spiral or oblique direction, so that the end of the slender semi-transparent thread may be readily found when it breaks. As the bobbins revolve with uniform velocity, they would soon wind on too fast, were their diameters so small at first as to become greatly thicker when they are filled. They are therefore made large, are not covered thick, but are frequently changed. The motion is communicated to that end of the engine shown in the figure.

975

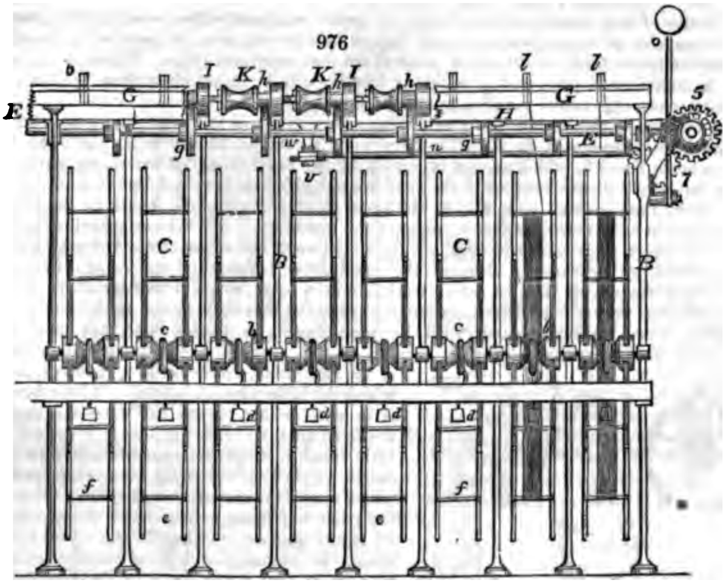


The wooden table A, shown here in cross section, is sometimes of great length, extending 20 feet, or more, according to the size of the apartment. Upon this the skeins are laid out. It is supported by the two strong slanting legs B, B, to which the bearings of the light reel C are made fast. These reels are called *swifts*, apparently by the same etymological casuistry as *lucus à non lucendo;* for they turn with reluctant and irregular slowness; yet they do their work much quicker than any of the old apparatus, and in this respect may deserve their name. At every eighth or tenth leg there is a projecting horizontal piece D, which carries at its end another horizontal bar *a*, called the knee rail, at right angles to the former. This protects the slender reels or swifts from the knees of the operatives.

These swifts have a strong wooden shaft *b*, with an iron axis passing longitudinally through it, round which they revolve, in brass bearings fixed near to the middle of the legs B. Upon the middle of the shaft *b*, a loose ring is hung, shown under *c*, in *fig.* 976, to which a light weight *d*, is suspended, for imparting friction to the reel, and thus preventing it from turning round, unless it be drawn with a gentle force, such as the traction of the thread in the act of winding upon the bobbin.

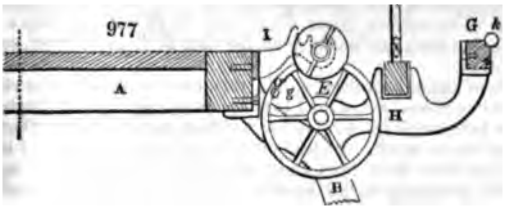
Fig. 796 is a front view of the engine. B, B, are the legs, placed at their appropriate distances (scale 1½ inch to the foot); C, C, are the swifts. By comparing *figs.* 975 and 976, the structure of the swifts will be fully understood. From the wooden shaft *b*, six slender wooden (or iron) spokes *e*, *e*, proceed, at equal angles to each other; which are bound together by a cord *f*, near their free ends, upon the transverse line *f* of which cord, the silk thread is wound, in a hexagonal form; due tension being given to the circumferential cords, by sliding them out from the centre. Slender wooden rods are set between each pair of spokes, to stay them, and to keep the cord tight. E is one of the two horizontal shafts, placed upon each side of the *engine*, to which are affixed a number of light iron pulleys *g*, *g* (shown on a double scale in *fig.* 977. (These serve, by friction, to drive the bobbins which rest upon their peripheries.

976



To the table A, *fig.* 975, are screwed the light cast-iron slot-bearings I, I, wherein the horizontal spindles or skewers rest, upon which the bobbins revolve. The spindles (see F, *fig.* 981) carry upon one end a little wooden pulley *h*, whereby they press and revolve upon the larger driving pulleys *g*, of the shaft E. These pulleys are called *stars* by our workmen. The other ends of the spindles, or skewers, are cut into screws, for attaching the swivel nuts *i* (*fig.* 981), by which the bobbins K, K, are made fast to their respective spindles. Besides the slots, above described, in which the spindles rest when their friction pulleys *h*, are in contact with the moving stars *g*, there is another set of slots in the bearings, into which the ends of the spindles may be occasionally laid, so as to be above the line of contact of the rubbing periphery of the star *g*, in case the thread of any bobbin breaks. Whenever the girl has mended the thread, she replaces the bobbin-spindle in its deeper slot-bearings, thereby bringing its pulley once more into contact with the star, and causing it to revolve.

977



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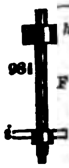

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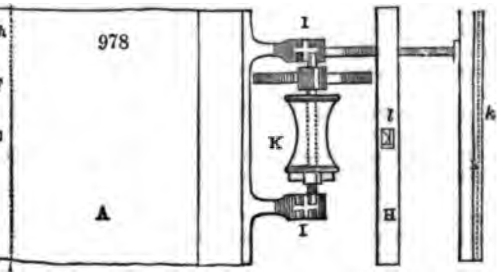
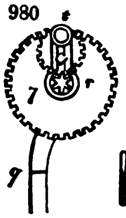


G is a long ruler or bar of wood, which is supported upon every eighth or twelfth leg B, B. (The figure being, for convenience of the page, contracted in length, shows it at every sixth leg.) To the edge of that bar the smooth glass rods *k*, are made fast, over which the threads glide from the swifts, in their way to the bobbins. H is the guide bar, which has a slow traverse or seesaw motion, sliding in slots at the top of the legs B, where they support the bars G. Upon the guide bar H, the guide pieces *l*, *l*, are made fast. These consist of two narrow, thin, upright plates of iron, placed endwise together, their contiguous edges being smooth, parallel, and capable of approximation to any degree by a screw, so as to increase or diminish at pleasure the ordinary width of the vertical slit that separates them. Through this slit the silk thread must pass, and, if rough or knotty, will be either cleaned or broken; in the latter case, it is neatly mended by the attendant girl.

The motions of the various parts of the *engine* are given as follows. Upon the end of the machine, represented in *fig.* 975, there are attached to the shafts E (*fig.* 976), the bevel wheels 1 and 2, which are set in motion by the bevel wheels 3 and 4, respectively. These latter wheels are fixed upon the shaft *m*, *fig.* 975. *m* is moved by the main steam shaft which runs parallel to it, and at the same height, through the length of the engine apartment, so as to drive the whole range of the machines. 5 is a loose wheel or pulley upon the shaft *m*, working in gear with a wheel upon the steam shaft, and which may be connected by the clutch *n*, through the hand lever or gearing rod *o* (*figs.* 975 and 976), when the engine is to be set at work. 6 is a spur wheel upon the shaft *m*, by which the stud wheel 7 is driven, in order to give the traverse motion to the guide bar H. This wheel is represented, with its appendages, in double size, *figs.* 979 and 980, with its boss upon a stud *p*, secured to the bracket *q*. In an eccentric hole of the same boss, another stud *r*, revolves, upon which the little wheel *s*, is fixed. This wheel *s*, is in gear with a pinion cut upon the end of the fixed stud *p*; and upon it is screwed the little crank *t*, whose collar is connected by two rods *u* (*figs.* 975 and 976), to a cross-piece *v* which unites the two arms *w*, that are fixed upon the guide bar H, on both sides of the machine. By the revolution of wheel 7, the wheel *s* will cause the pinion of the fixed stud *p* to turn round. If that wheel bear to the pinion the proportion of 4 to 1, then the wheel *s* will make, at each revolution of the wheel 7, one fourth of a revolution; whereby the crank *t* will also rotate through one fourth of a turn, so as to be brought nearer to the centre of the stud, and to draw the guide bar so much less to one side of its mean position. At the next revolution of wheel 7, the crank *t* will move through another quadrant, and come still nearer to the central position, drawing the guide bars still less aside, and therefore causing the bobbins to wind on more thread in their middle than towards their ends. The contrary effect would ensue, were the guide bars moved by a single or simple crank. After four revolutions of the wheel 7, the crank *t* will stand once more as shown in *fig.* 980, having moved the bar H through the whole extent of its traverse. The bobbins, when filled, have the appearance represented in *fig.* 982; the thread having been laid on them all the time in diagonal lines, so as never to coincide with each other.

980



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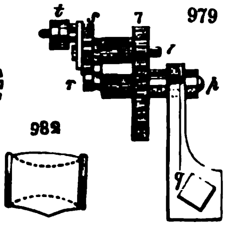


982

Doubling is the next operation of the silk throwster. In this process, the threads of two or three of the bobbins, filled as above, are wound together in contact upon a single bobbin. An ingenious device is here employed to stop the winding-on the moment that one of these parallel threads happens to break. Instead of the swifts or reels, a creel is here mounted for receiving the bobbins from the former machine, two or three being placed in one line over each other, according as the threads are to be doubled or trebled. Though this machine is in many respects like the *engine*, it has some additional parts, whereby the bobbins are set at rest, as above mentioned, when one of the doubling threads gets broken.

Fig. 983 is an end view, from which it will be perceived that the machine is, like the preceding, a double one, with two working sides.

Fig. 984 is a front view of a considerable portion of the machine.

Fig. 985 shows part of a cross section, to explain minutely the mode of winding upon a single bobbin.

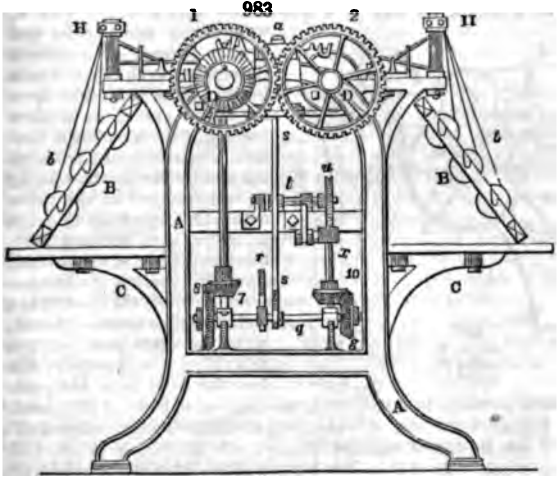
Fig. 986 is the plan of the parts shown in *fig.* 985; these two figures being drawn to double the scale of *figs.* 983 and 984.

A, A, *figs.* 983 and 984, are the end frames, connected at their tops by a wooden stretcher, or *bar-beam*, *a*, which extends through the whole length of the machine; this bar is shown also in *figs.* 985 and 986.

B, B, are the creels upon each side of the machine, or bobbin bearers, resting upon wooden beams or boards, made fast to the arms or brackets C, about the middle of the frames A.

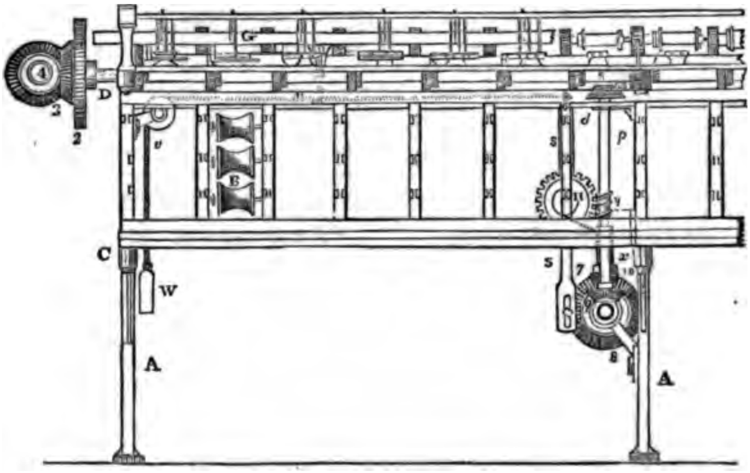
D, D, are two horizontal iron shafts, which pervade the whole machine, and carry a series of light moveable pulleys, called *stars*, *c*, *c*, (*figs.* 985, 986,) which serve to drive the bobbins E, E, whose fixed pulleys rest upon their peripheries, and are therefore turned simply by friction. These bobbins are screwed by swivel nuts *e*, *e*, upon spindles, as in the silk engine. Besides the small friction pulley or boss, *d*, seen best in *fig.* 986, by which they rest upon the star pulleys *c*, *c*, a little ratchet wheel *f*, is attached to the other end of each bobbin. This is also shown by itself at *f*, in *fig.* 987.

983



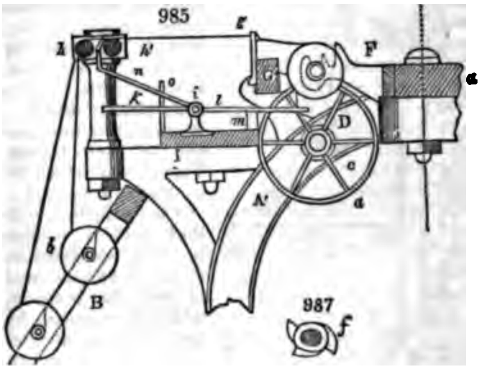
The spindles with their bobbins revolve in two slot-bearings F, F, *fig.* 986, screwed to the bar-beam *a*, which is supported by two or three intermediate upright frames, such as A′. The slot-bearings F, have also a second slot, in which the spindle with the bobbin is laid at rest, out of contact of the *star* wheel, while its broken thread is being mended. G is the guide bar (to which the cleaner slit pieces *g*, *g*, are attached), for making the thread traverse to the right and the left, for its proper distribution over the surface of the bobbin. The guide bar of the doubling machine is moved with a slower traverse than in the engine; otherwise, in consequence of the different obliquities of the paths, the single threads would be readily broken. *h*, *h*, is a pair of smooth rods of iron or brass, placed parallel to each of the two sides of the machine, and made fast to the standards H, H, which are screwed to brackets projecting from the frames A, A′. Over these rods the silk threads glide, in their passage to the guide wires *g*, *g*, and the bobbins E, E. I, I, is the *lever board* upon each side of the machine, upon which the slight brass bearings or fulcrums *i*, *i*, one for each bobbin in the creel, are made fast. This board bears the *balance-lever k*, *l*, with the *fallers n*, *n*, *n*, which act as dexterous fingers, and stop the bobbin from winding-on the instant a thread may chance to break. The levers *k*, *l*, swing upon a fine wire axis, which passes through their props *i*, *i*, their arms being shaped rectangularly, as shown at *k*, *k′*, *fig.* 986. The arm *l*, being heavier than the arm *k*, naturally rests upon the ridge bar *m*, of the lever board I. *n*, *n*, *n*, are three wires, resting at one of their ends upon the axis of the fulcrum *i*, *i*, and having each of their other hooked ends suspended by one of the silk threads, as it passes over the front steel rod *h*. and under

H 984



k′. These faller wires, or stop fingers, are guided truly in their up-and-down motions with the thread, by a cleaner-plate *o*, having a vertical slit in its middle. Hence, whenever any thread happens to break, in its way to a winding-on bobbin E, the wire n, which hung by its eyelet end to that thread, as it passed through between the steel rods in the line of *k*, *k′*, falls upon the lighter arm of the balance lever *k*, *l*, weighs down that arm *k*, consequently jerks up the arm *l*, which pitches its tip or end into one of the three notches of the ratchet or catch wheel *f* (*figs.* 986 and 987), fixed to the end of the bobbin. Thus its motion is instantaneously arrested, till the girl has had leisure to mend the thread, when she again hangs up the faller wire n, and restores the lever *k*, *l*, to its horizontal position. If, meanwhile, she took occasion to remove the winding bobbin out of the sunk slot-bearing, where pulley *d* touches the *star* wheel *c*, into the right-hand upper slot of repose, she must now shift it into its slot of rotation.

985



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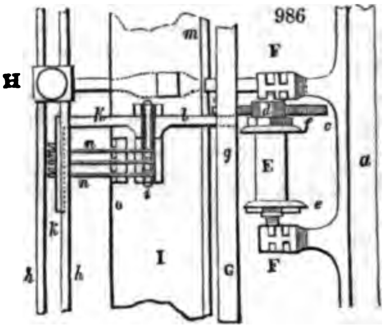
986



The motions are given to the doubling machine in a very simple way. Upon the end of the framing, represented in *fig.* 983, the shafts D, D, bear two spur wheels 1 and 2, which work into each other. To the wheel 1, is attached the bevel wheel 3, driven by another bevel wheel 4 (*fig.* 984), fixed to a shaft that extends the whole length of the apartment, and serves, therefore, to drive a whole range of machines. The whêel 4 may be put in gear with the shaft, by a clutch and gear-handle, as in the silk *engine*, and thereby it drives two shafts, by the one transmitting its movement to the other.

The traverse motion of the guide bar e, is effected as follows: — Upon one of the shafts D, there is a bevel wheel 5, driving the bevel wheel 6, upon the top of the upright shaft *p* (*fig.* 984, to the right of the middle); whence the motion is transmitted to the horizontal shaft *q*, below, by means of the bevel wheels 7 and 8. Upon this shaft *q*, there is a heart-wheel *r*, working against a roller which is fixed to the end of the lever *s*, whose fulcrum is at *t*, *fig.* 983. The other end of the lever *s*, is connected by two rods (shown by dotted lines in *fig.* 984) to a brass piece which joins the arms *u* (*fig.* 984), of the guide bars G. To the same cross piece a cord is attached, which goes over a roller *v*, and suspends a weight *w*, by means of which the level *s*, is pressed into contact with the heart-wheel *r*. The fulcrum *t*, of the lever *s*, is a shaft which is turned somewhat eccentric, and has a very slow rotatory motion. Thus the guide bar, after each traverse, neccessarily winds the silk in variable lines, to the side of the preceding threads.

The motion is given to this shaft in the following way. Upon the horizontal shaft *q*, there is a bevel wheel *g* (*figs.* 983 and 984), which drives the wheel 10 upon the shaft *x*; on whose upper end, the worm *y* works in the wheel 11, made fast to the said eccentric shaft *t*; round which the lever *s* swings or oscillates, causing the guide bars to traverse.

The spinning silk-mill.—The machine which twists the silk threads, either in their single or doubled state, is called the spinning mill. When the raw singles are first twisted in one direction, next doubled, and then twisted together in the opposite direction, an exceedingly wiry, compact thread, is produced, called *organzine*. In the spinning mill, either the singles or the doubled silk, while being unwound from one set of bobbins, and wound upon another set, is subjected to a regular twisting operation; in which process the thread is conducted as usual through guides, and coiled diagonally upon the bobbins by a proper mechanism.

Fig. 988 exhibits an end view of the spinning mill; in which four working lines are shown; two tiers upon each side, one above the other. Some spinning mills have three working tiers upon each side; but as the highest tier must be reached by a ladder or platform, this construction is considered by many to be injudicious.

988

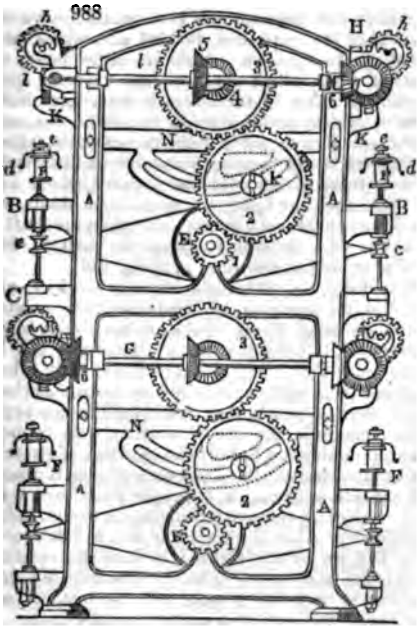


Fig. 989, is a front view, where, as in the former figure, the two working lines are shown.

Fig. 990, is a cross section of a part of the machine, to illustrate the construction and play of the working parts; *figs.* 996, 997, are other views of *fig.* 990.

Fig. 991, shows a single part of the machine, by which the bobbins are made to revolve.

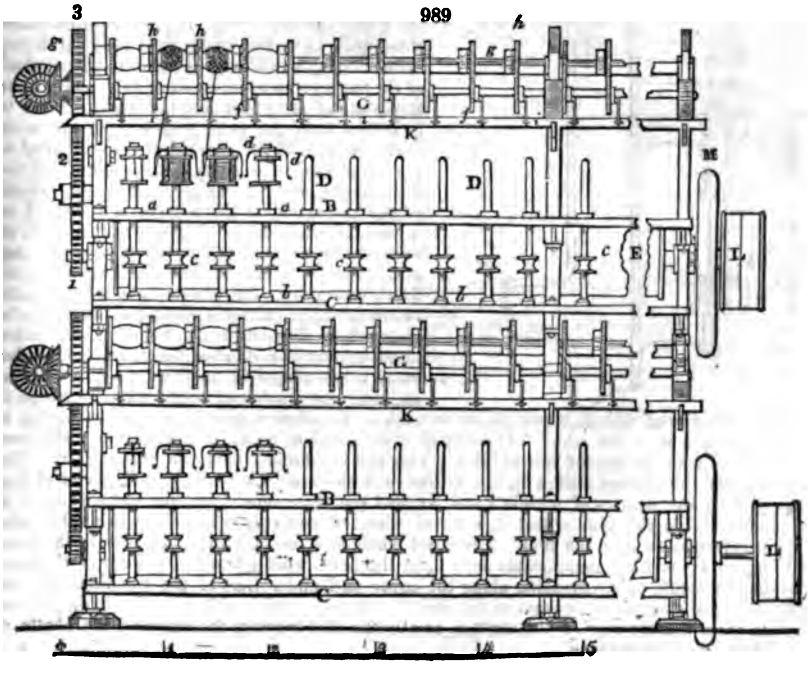
Figs. 992, and 993, show a different mode of giving the traverse to the guide bars, than that represented in *fig.* 990.

Figs. 994, and 995, show the shape of the full bobbins, produced by the action of these two different traverse motions.

The upper part of the machine being exactly the same as the under part, it will be sufficient to explain the construction and operation of one of them.

A, A, are the end upright frames or standards, between which are two or three intermediate standards, according to the length of the machine. They are all connected at their sides by beams B and C, which extend the whole length of the machines. D, D, are the spindles, whose top bearings *a*, *a*, are made fast to the beams B, and their bottoms turn in hard brass steps, fixed to the bar C. These two bars together are

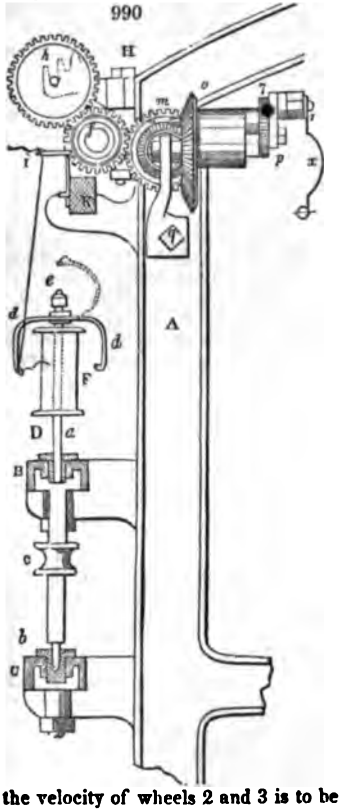
989



called, by the workmen, the spindle box. The standards A, A, are bound with cross bars N, N.

c, *c*, are the wharves or whorls, turned by a band from the horizontal tin cylinder in the lines of E, E, *fig.* 988, lying in the middle line between the two parallel rows of spindles D, D. F, F, are the bobbins containing the untwisted doubled silk, which are simply pressed down upon the taper end of the spindles. *d*, *d*, are little fliers, or forked wings of wire, attached to washers of wood, which revolve loose upon the tops of the said bobbins F, and round the spindles. One of the wings is sometimes bent upwards, to serve as a guide to the silk, as shown by dotted lines in *fig.* 990. *e*, *e*, are pieces of wood pressed upon the tops of the spindles, to prevent the fliers from starting off by the centrifugal force. G, are horizontal shafts bearing a number of little spur wheels *f*, *f*. H, are slot-bearings, similar to those of the doubling-machine, which are fixed to the end and middle frames. In these slots, the light square cast-iron shafts or spindles *g*, *fig.* 989, are laid, on whose end the spur wheel *h* is cast; and when the shaft *g* lies in the front slot of its bearing, it is in gear with the wheel *f*, upon the shaft G; but when it is laid in the back slot, it is out of gear, and at rest. See F, F, *fig.* 986.

990



Upon these little cast-iron shafts or spindles *g*, *fig.* 991, the bobbins or blocks I, are thrust, for receiving, by winding-on, the twisted or spun silk. These blocks are made of a large diameter, in order that the silk fibres may not be too much bent; and they are but slightly filled, at each successive charge, lest, by increasing their diameter too much, they should produce too rapid an increase in the rate of winding, with proportional diminution in the twist, and risk of stretching or tearing the silk. They are therefore the more frequently changed. K, K, are the guide bars, with the guides *i*, *i*, through which the silk passes, being drawn by the revolving bobbins I, and delivered or laid on by the fliers *d*, *d*, from the rotatory twisting-bobbins F. The operation of the machine is therefore simple, and the motions are given to the parts in a manner equally so.

Upon the shaft of the tin cylinder or drum, exterior to the frame, the usual fast and loose pulleys, or riggers, L, L′, are mounted, for driving the whole machine. These riggers are often called steam-pulleys by the workmen, from their being connected by bands with the steam-driven shaft of the factory. In order to allow the riggers upon the shafts of the upper and the under drums to be driven from the same pulley upon the main shaft, the axis of the under drum is prolonged at L, L′, and supported at its end, directly from the floor, by an upright bearing. Upon the shafts of the tin cylinders there is also a fly-wheel M, to equalize the motion. Upon the other ends of these shafts, namely, at the end of the spinning-mill, represented in *fig.* 988, the pinions 1 are fixed, which drive the wheels 3, by means of the intermediate or carrier wheel 2; called also the plate wheel, from its being hollowed somewhat like a trencher. 1, is called the change-pinion, because it is changed for another, of a different size and different number of teeth, when a change in the velocity of wheels 2 and 3 is to be made. To allow a greater or smaller pinion to be applied at 1, the wheel 2 is mounted upon a stud *k*, which is moveable in a slot concentric with the axis of the wheel 3. This slot is a branch from the cross bar N. The smaller the change-pinion is, the nearer will the stud *k* approach to the vertical line joining the centres of wheels 1 and 3; and the more slowly will the plate wheel 2 be driven. To the spur wheel 3, a bevel wheel 4, is fixed, with which the other also revolves loose upon the stud. The bevel wheel 5, upon the shaft *l*, is driven by the bevel wheel 4; and it communicates motion, by the bevel wheels 6 and 7, to each of the horizontal shafts G, G, extending along the upper and under tiers of the machine. At the left-hand side of the top part of *fig.* 988, the two wheels 6 and 7 are omitted, on purpose to show the bearings of the shaft G, as also the slot-bearings for carrying the shafts or skewers of the bobbins.

If it be desired to communicate twist in the opposite direction to that which would be given by the actual arrangement of the wheels, it is necessary merely to transpose the carrier wheel 2, from its present position on the right hand of pinion 1, to the left of it, and to drive the tin cylinder by a crossed or close strap, instead of a straight or open one.

The traverse motion of the guide is given here in a similar way to that of the engine, (*fig.* 975.) Near one of the middle or cross-frames of the machine (see *fig.* 990) the wheel *f*, in gear with a spur wheel *h*, upon one of the block-shafts, drives also a spur wheel *m*, that revolves upon a stud, to which wheel is fixed a bevel wheel *n*, in gear with the bevel wheel *o*. To wheel *o*, the same mechanism is attached as was described under *figs.* 979 and 980, and which is here marked with the same letters.

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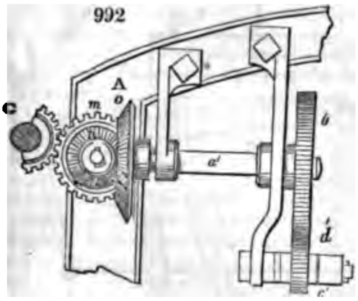

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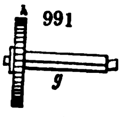

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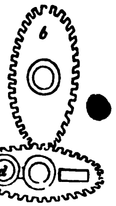

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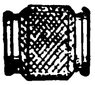

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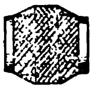
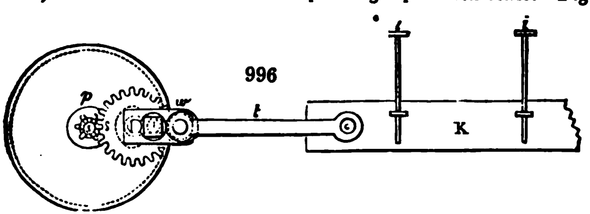


To the crank-knob *r*, *fig.* 990, a rod *x*, is attached, which moves or traverses the guide bar belonging to that part of the machine; to each machine one such apparatus is fitted. In *figs.* 992 and 993 another mode of traversing the guide bar is shown, which is generally used for the coarser qualities of silk. Near to one of the middle frames, one of the wheels *f*, in gear with the spur wheel *m*, and the bevel wheel *n*, both revolving on one stud, gives motion also to the wheel *o*, fixed upon a shaft *a'*, at whose other end the elliptical wheel *b'* is fixed, which drives a second elliptical wheel *c'*, in such a way that the larger diameter of the one plays in gear with the smaller diameter of the other; the teeth being so cut as to take into each other in all positions. The crank-piece *d'* is screwed upon the face of the wheel *c'*, at such a distance from its centre as may be necessary to give the desired length of traverse motion to the guide bar for laying the silk spirally upon the blocks. The purpose of the elliptical wheel is to modify the simple crank motion, which would wind on more silk at the ends of the bobbins than in their middle, and to effect an equality of winding-on over the whole surface of the blocks. In *fig.* 993 the elliptical wheels are shown in front, to illustrate their mode of operating upon each other. *Fig.* 994 is a block filled by the motion of the eccentric, *fig.* 990; and *fig.* 995 is a block filled by the elliptical mechanism. As the length of the motions of the bar in the latter construction remains the same during the whole operation, the silk, as it is wound on the blocks, will slide over the edges, and thereby produce the flat ends of the barrel in *fig.* 995. The conical ends of the block (*fig.* 994) are produced by the continually shortened motions of the guide bar, as the stud approaches, in its sun-and-planet rotation, nearer to the general centre.

996



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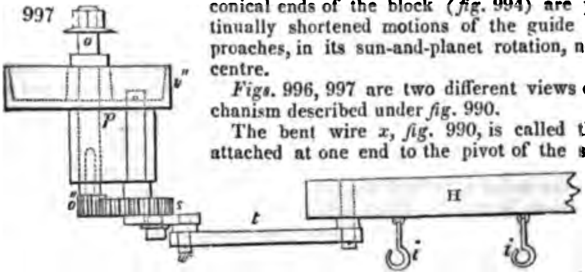


Figs. 996, 997 are two different views of the differential mechanism described under *fig.* 990.

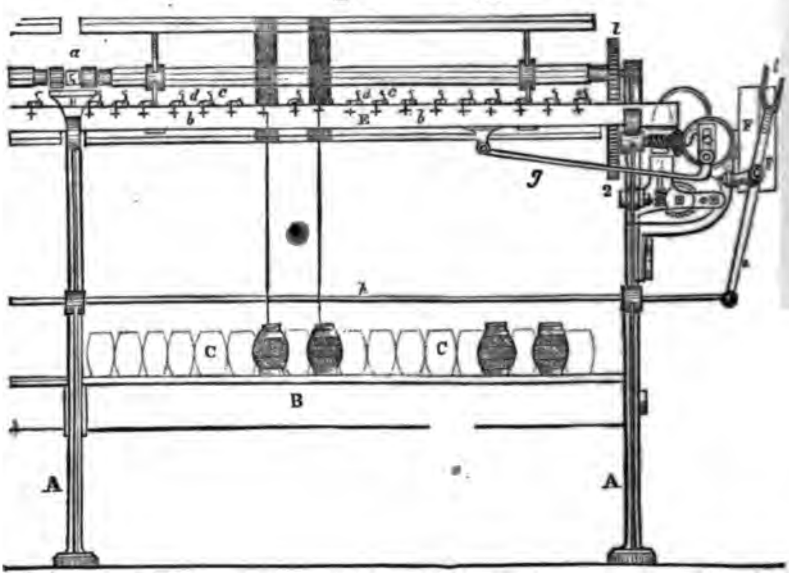
The bent wire *x*, *fig.* 990, is called the guider iron. It is attached at one end to the pivot of the sun-and-planet wheelwork *t*, *s*, *o*, and at the other to the guide bar *f*, *f*, *fig.* 989. The silk threads pass through the guides, as already explained. By the motion communicated to the guide bar (*guider*), the diamond pattern is produced, as shown in *fig.* 994.

THE SILK AUTOMATIC REEL.

In this machine, the silk is unwound from the blocks of the throwing-mill, and formed into hanks for the market. The blocks being of a large size, would be productive of much friction, if made to revolve upon skewers thrust through them, and would cause frequent breakage of the silk. They are, therefore, set with their axes upright upon a board, and the silk is drawn from their surface, just as the weft is from a cop in the shuttle. On this account the previous winding-on must be executed in a very regular manner; and preferably as represented in *fig*. 994.

Fig. 998 is a front view of the reel; little more than one half of it being shown. *Fig*. 999 is an end view. Here the steam pulleys are omitted, for fear of obstructing the view of the more essential parts. A, A, are the two end framings, connected by mahogany stretchers, which form the table B, for receiving the bobbins C, C, which are sometimes weighted at top with a lump of lead, to prevent their tumbling. D is the reel, consisting of four long laths of wood, which are fixed upon iron frames, attached to an octagonal wooden shaft. The arm which sustains one of these laths is capable of being bent inwards, by loosening a tightening hook, so as to permit the hanks, when finished, to be taken off, as in every common reel.

998



The machine consists of two equal parts, coupled together at *a*, to facilitate the removal of the silk from either half of the reel; the attendant first lifting the one part, and then the other. E is the guide bar, which by a traverse motion causes the silk to be wound on in a cross direction. *b* and *c* are the wire guides, and *d* are little levers lying upon the cloth covered guide bar E. The silk, in its way from the block to the reel, passes under these levers, by which it is cleaned from loose fibres.

On the other end of the shaft of the reel, the spur wheel 1 is fixed, which derives motion from wheel 2, attached to the shaft of the steam-pulley F. Upon the same shaft there is a bevel wheel 3, which impels the wheel 4 upon the shaft *e*; to whose end a plate is attached, to which the crank *f* is screwed, in such a way as to give the proper length of traverse motion to the guide bar E, connected to that crank or eccentric stud by the jointed rod *g*. Upon the shaft of the steam-pulleys F, there is a worm or endless screw, to the left of *f*, *fig*. 999, which works in a wheel 5, attached to the short upright shaft *h* (*fig*. 998). At the end of *h*, there is another worm, which works in a wheel 6; at whose circumference there is a stud *i*, which strikes once at every revolution against an arm attached to a bell, seen to the left of G; thus announcing to the reel tenter that a measured length of silk has been wound upon her reel. *e* is a rod or handle, by which the fork *l*, with the strap, may be moved upon the fast or loose pulley, so as to set on or arrest the motion at pleasure.

Throwsters submit their silk to scouring and steaming processes. They soak the hanks, as imported, in lukewarm soap-water in a tub; but the bobbins of the twisted single silk from the spinning mill are enclosed within a wooden chest, and exposed to the opening action of steam for about ten minutes. They are then immersed in a cistern of warm water, from which they are transferred to the doubling frame.

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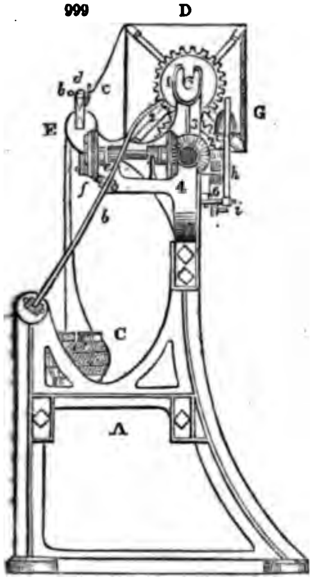


The wages of the workpeople in the silk-throwing mills of Italy are about one half of their wages in Manchester; but this difference is much more than counterbalanced by the protecting duty of 2*s.* 10*d.* a pound upon thrown silk, and the superior machinery of our mills. In 1832, there was a power equal to 342 horses engaged in the silk-throwing mills of Manchester, and of about 100 in the mills of Derby. The power employed in the other silk mills of England and Scotland has not been recorded.

There is a peculiar kind of silk called *marabout*, containing generally three threads, made from the white Novi raw silk. From its whiteness, it takes the most lively and delicate colors without the discharge of its gum. After being made into tram by the single twist upon the spinning mill, it is reeled into hanks, and sent to the dyer without further preparation. After being dyed, the throwster re-winds and re-twists it upon the spinning mill, in order to give it the whipcord hardness which constitutes the peculiar feature of marabout. The cost of the raw Novi silk is 19*s.* 6*d.* a pound; of throwing it into tram, 2*s.* 6*d.*; of dyeing, 2*s.*; of re-winding and re-twisting, after it has been dyed, about 5*s.*; of waste, 2*s.*, or 10 per cent.: the total of which sum is 31*s.*; being the price of one pound of marabout in 1832.

An ESTIMATE of the Annual Quantities of SILK produced or exported from the several Countries in the World, exhibiting also the Countries to which exported.

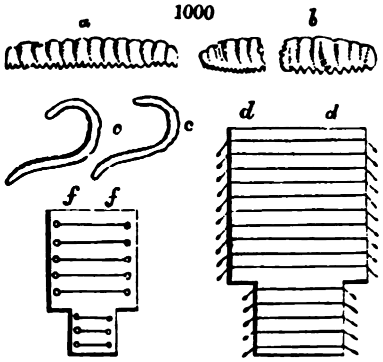
Countries whence exported.	Quantities.	Countries to which exported.	Quantities.
Italy exports	34,000 bales of 225 small lbs.		Bales.
France produces	10,500 . . { 73½ kils., or	} England -	28,000
India and Bengal export	9,500 . . { 128½ Vienna lbs.	} France -	22,000
Persia	7,500 . . 162 lbs. English	Prussia -	7,600
China	4,000 . .	Russia -	6,400
Asia Minor	3,500 . .	Austria and Germany -	5,000
Levant, Turkey, and Archipelago export	3,500 . .	Switzerland	5,000
Spain exports	1,500 . .		
Total	74,000 bales.	Total -	74,000

Note.—These estimates exclude the silk manufactured in Italy.

The declared value of the silk manufactures exported from the United Kingdom in 1836, was 917,822*l.*; and in 1837, only 494,569. The deficit in the last year was owing to the commercial crisis in the United States; which country took, the preceding year, our silk goods to the value of 524,301*l.*

SILKWORM GUT, for angling, is made as follows:—Select a number of the best and largest silkworms, just when they are beginning to spin; which is known by their refusing to eat, and having a fine silk thread hanging from their mouths. Immerse them in strong vinegar, and cover them closely for twelve hours, if the weather be warm, but two or three hours longer, if it be cool. When taken out, and pulled asunder, two transparent guts will be observed, of a yellow green color, as thick as a small straw, bent double. The rest of the entrails resembles boiled spinage, and therefore can occasion no mistake as to the silk-gut. If this be soft, or break upon stretching it, it is a proof that the worm has not been long enough under the influence of the vinegar. When the gut is fit to draw out, the one end of it is to be dipped into the vinegar, and the other end is to be stretched gently to the proper length. When thus drawn out, it must be kept extended on a thin piece of board, by putting its extremities into slits in the end of the wood, or fastening them to pins, and then exposed in the sun to dry. Thus genuine silk-gut is made in Spain. From the manner in which it is dried, the ends are always more or less compressed or attenuated.* *Fig.* 1000, *a*, is the silkworm; *b*, the worm torn asunder; *c*, *c*, the guts; *d*, *d*, a board slit at the ends, with the gut to dry; *f*, *f*, a board with wooden pegs, for the same purpose.

1000



SILVER (*Argent*, Fr.; *Silber*, Germ.) was formerly called a *perfect* metal, because heat alone revived its oxyde, and because it could pass unchanged through fiery trials, which apparently destroyed most other metals. The distinctions, perfect, imperfect, and noble, are now justly rejected. The bodies of this class are all equal in metallic nature, each being endowed merely with different relations to other forms of matter, which serve to characterize it, and to give it a peculiar value.

When pure and planished, silver is the brightest of the metals. Its specific gravity in the ingot is 10·47; but, when condensed under the hammer or in the coining press, it becomes 10·6. It melts at a bright red heat, a temperature estimated by some as equal to 1280° Fahr., and by others to 22° Wedgewood. It is exceedingly malleable and ductile; affording leaves not more than $\frac{1}{100000}$ of an inch thick, and wire far finer than a human hair.

By Sickingen's experiments, its tenacity is, to that of gold and platinum, as the numbers 19, 15, and 26¼; so that it has an intermediate strength between these two metals. Pure atmospheric air does not affect silver, but that of houses impregnated with sulphureted hydrogen, soon tarnishes it with a film of brown sulphuret. It is distinguished chemically from gold and platinum by its ready solubility in nitric acid, and from almost all other metals, by its saline solutions affording a curdy precipitate with a most minute quantity of sea salt, or any soluble chloride.

Silver occurs under many forms in nature:—

1. *Native silver* possesses the greater part of the above properties; yet, on account of its being more or less alloyed with other metals, it differs a little in malleability, lustre, density, &c. It sometimes occurs crystallized in wedge-form octahedrons, in cubes, and cubo-octahedrons. At other times it is found in dendritic shapes, or arborescences, resulting from minute crystals implanted upon each other. But more usually it presents itself in small grains without determinable form, or in amorphous masses of various magnitude.

The *gangues* (mineral matrices) of native silver are so numerous, that it may be said to occur in all kinds of rocks. At one time it appears as if filtered into their fissures, at another as having vegetated on their surface, and at a third, as if impasted in their substance. Such varieties are met with principally in the mines of Peru.

The native metal is found in almost all the silver mines now worked; but especially in that of Kongsberg in Norway, in carbonate and fluate of lime, &c.; at Schlangenberg in Siberia, in a sulphate of barytes; at Allemont, in a ferruginous clay, &c. In the article MINES, I have mentioned several large masses of native silver that have been discovered in various localities.

The metals most usually associated with silver in the native alloy are gold, copper, arsenic, and iron. At Andreasberg and Guadalcanal it is alloyed with about 5 per cent. of arsenic. The auriferous native silver is the rarest; it has a brass-yellow color.

2. *Antimonial silver.*—This rare ore is yellowish-blue; destitute of malleability; even very brittle; spec. grav. 9·5. It melts before the blowpipe, and affords white fumes of oxyde of antimony; being readily distinguished from arsenical iron, and arsenical cobalt, by its lamellar fracture. It consists of from 76 to 84 of silver, and from 24 to 16 of antimony.

3. *Mixed antimonial silver.*—At the blowpipe it emits a strong garlic smell. Its constituents are, silver 16, iron 44, arsenic 35, antimony 4. It occurs at Andreasberg.

4. *Sulphuret of silver.*—This is an opaque substance, of a dark-gray or leaden hue; slightly malleable, and easily cut with a knife, when it betrays a metallic lustre. The silver is easily separated by the blowpipe. It consists of, 13 of sulphur to 89 of silver,

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* Nobb's Art of Trolling.

by experiment; 13 to 87 are the theoretic proportions. Its spec. grav. is 6·9. It occurs crystallized in most silver mines, but especially in those of Freyberg, Joachimsthal in Bohemia, Schemnitzin, Hungary, and Mexico.

5. *Red sulphuret of silver; silver glance.*—Its spec. grav. is 5·7. It contains from 84 to 86 of silver.

6. *Sulphureted silver, with bismuth.*—Its constituents are, lead 35, bismuth 27, silver 15, sulphur 16, with a little iron and copper. It is rare.

7. *Antimoniated sulphuret of silver*, the red silver of many mineralogists, is an ore remarkable for its lustre, color, and the variety of its forms. It is friable, easily scraped by the knife, and affords a powder of a lively crimson red. Its color in mass is brilliant red, dark red, or even metallic reddish-black. It crystallizes in a variety of forms. Its constituents are,—silver from 56 to 62; antimony from 16 to 20; sulphur from 11 to 14; and oxygen from 8 to 10. The antimony being in the state of a purple oxyde in this ore, is reckoned to be its coloring principle. It is found in almost all silver mines; but principally in those of Freyberg, Sainte-Marie-aux-Mines, and Guadalcanal.

8. *Black sulphuret of silver*, is blackish, brittle, cellular, affording globules of silver at the blowpipe. It is found only in certain mines, at Allémont, Freyberg; more abundantly in the silver mines of Peru and Mexico. The Spaniards call it *negrillo*.

9. *Chloride of silver, or horn silver.*—In consequence of its semi-transparent aspect, its yellowish or greenish color, and such softness that it may be cut with the nail, this ore has been compared to horn, and may be easily recognised. It melts at the flame of a candle, and may be reduced when heated along with iron or black flux, which are distinctive characters. It is seldom crystallized; but occurs chiefly in irregular forms, sometimes covering the native silver as with a thick crust, as in Peru and Mexico. Its density is only 4·74.

Chloride of silver sometimes contains 60 or 70 per cent. of clay; and is then called butter-milk ore, by the German miners. The blowpipe causes globules of silver to sweat out of it. This ore is rather rare. It occurs in the mines of Potosi, of Annaberg, Freyberg, Allémont, Schlangenberg, in Siberia, &c.

10. *Carbonate of silver*, a species little known, has been found hitherto only in the mine of S. Wenceslas, near Wolfache.

TABLE of the Quantities of SILVER brought into the Market every year, on an average, from 1790 to 1802.

Old Continent.	Lbs. Avoird.	New Continent.	Lbs. Avoird.
ASIA.			
Siberia - - -	38,500	Central America - -	1,320,000
EUROPE.			
Hungary - -	44,000	South America - -	605,000
Austrian States - -	11,000		
Hartz and Hessia -	11,000		
Saxony - - -	22,000		
Norway - - - -	22,000		
Sweden - - -	11,000		
France - - -			
Spain - - -			
Total of the Old Continent	159,500	Total of the New Continent	1,925,000

Thus the New Continent furnished twelve times more silver than the old. For more detailed statistics of silver, see the end of the article.

The following is Mr. Ward's description of the treatment of silver ores in Mexico:—

"After returning from San Augustin," says he, "I passed the whole of the afternoon at the *hacienda* (metallurgic works) of Salgado, in which the ores of the Valenciana mine are reduced. The *hacienda*, of which a representation is given below, *fig.* 1001, contains forty-two crushing-mills, called *arrastres*, and thirty-six stampers. The ore, on being extracted from the mine, is placed in the hands of the *pepenadores*, men and women, who break all the larger pieces with hammers, and after rejecting those in which no metallic particles are contained, divide the rest into three classes" (inferior, middling, and rich). "These are submitted to the action of the *morteros* (stamps), one of which, of eight stampers, is capable of reducing to powder ten cargas of ore (each of 350 lbs.) in twenty-four hours. This powder not being thought sufficiently fine for the quicksilver to act upon with proper effect, it is transferred from the *morteros* to the *arrastres* (crushing-mills, see wood-cut), in which water is used. Each of these reduces to a fine impalpable metalliferous mud, six quintals (600 lbs.) of powder in

24 hours. At Guanajuato, where water-power cannot be obtained, the *arrastres* are worked by mules (see *fig.* 1001), which are kept constantly in motion at a slow pace, and are changed every 6 hours. The grinding-stones, as well as the sides and bottom of the mill itself, are composed of granite; four blocks of which revolve in each crushing-mill, attached to cross-bars of wood. This part of the operation is thought of great importance, for it is upon the perfection of the grinding that the saving of the quicksilver is supposed in a great measure to depend, in the subsequent amalgamation. The grinding is performed usually in a covered shed or gallery, which in a large *hacienda*, like Salgado, from the number of *arrastres* at work at the same time, is necessarily of considerable extent."

1001 *The Gallera of the Hacienda of Salgado.*

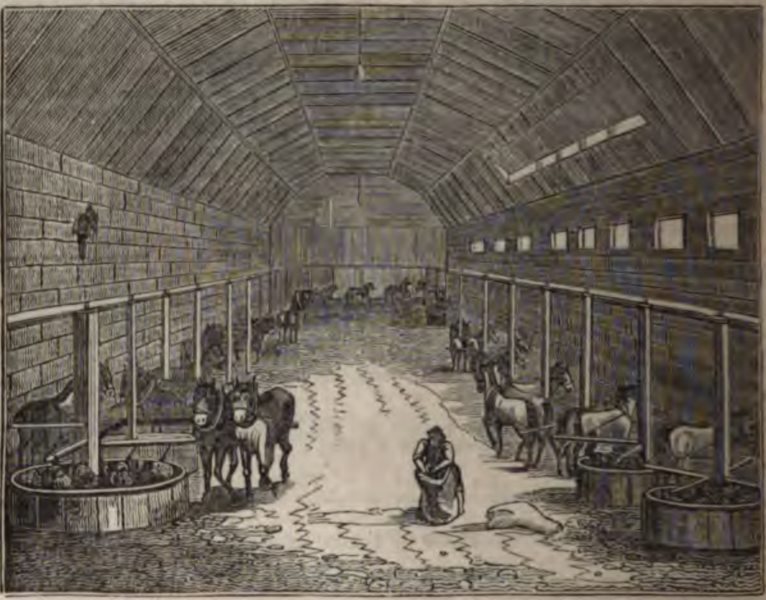

Fig. 1002, represents the rude grinding apparatus used at the *lavaderos*, or gold washings, in Chile. The streamlet of water conveyed to the hut of the gold washer, is received upon a large rude stone, whose flat surface has been hollowed out into a shallow basin, and in the same manner into 3 or 4 others in succession; the auriferous particles are thus allowed to deposite themselves in these receptacles, while the lighter earthy atoms, still suspended, are carried off by the running water. The gold thus collected is mixed with a quantity of ferruginous black sand and stony matter, which requires the process of trituration, effected by the very rude and simple *trapiche* shown in the figure; consisting of two stones, the under one being about three feet in diameter, and slightly concave. The upper stone is a large spherical boulder of syenitic granite, about two feet in diameter, having on its upper part two iron plugs fixed oppositely, to which is secured, by lashings of hide, a transverse horizontal pole of *canela* (cinnamon) *wood*, about 10 feet long; two men seated on the extremities of this lever, work it up and down alternately, so as to give to the stone a rolling motion, which is sufficient to crush and grind the materials placed beneath it. The washings thus ground, are subjected to the action of running water, upon inclined planes formed of skins, by which process the silicious particles are carried off, while a portion of the ferruginous matter, mixed with the heavier grains of gold, is extracted by a loadstone; it is again washed, till nothing but pure gold-dust remain. The whole process is managed with much dexterity; and if there were much gold to be separated, it

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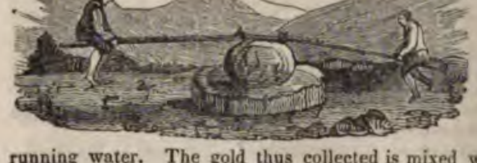
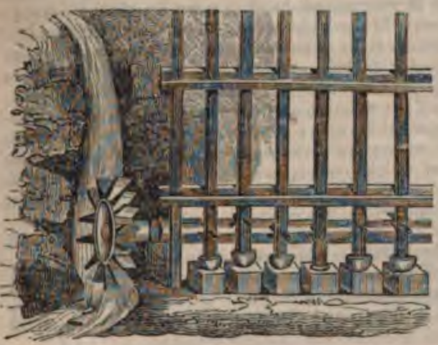


would afford very profitable employment; but generally the small quantity collected is sufficient only to afford subsistence to a few miserable families.

The *trapiche, ingenio*, or mill, for grinding the ores of silver, is a very simple piece of mechanism. A place is chosen where a small current of water, whose section will present a surface of six inches diameter, can be brought to a spot where it can fall perpendicularly ten or twelve feet; at this place a well is built of this depth, about 6 feet in diameter; in its centre is fixed an upright shaft, upon a central brass pin; it is confined above by a wooden collar. A little above its foot, the shaft has a small wheel affixed to it, round which are fixed a number of radiating spokes, shaped at the end somewhat like cups, and forming altogether a horizontal wheel, four feet in diameter. Upon the slanting edges of the cups, the water is made to strike with the force it has acquired in falling down a nearly perpendicular trough, scooped out of the solid trunk of a tree. This impression makes the wheel turn with a quick rotatory motion. The upright axis rises about 6 feet above the top of the well, at about half which height is inserted a small horizontal arm, four feet long, which serves as an axle to a ponderous mill-stone of granite, of from four to six feet diameter, which is made to roll on its edge in a circular trough, sometimes made of the same material, and sometimes of hard wood.

The weight of this quickly rolling stone effects the pulverization of the ore. In some cases, it is taken out in the dry state, and sifted; but more generally the separation of the finely ground particles is accomplished by the action of running water. For this purpose a small stream is made to trickle into the circular trough, by which the pounded ore is worked up into a muddy consistence, and the finer particles flow off with the excess of water, through a notch cut in the margin of the trough. This fine matter is received in little pools, where the pounded ore is left to settle; and the clear water being run off, the powder is removed from the bottom, and carried to the place of amalgamation.

1003



The *ingenios*, or stamping-mills, are driven by a small breast water-wheel, of five feet diameter, and one foot broad. *Fig.* 1003 will give a sufficient idea of their construction. The long horizontal shaft, fixed on the axis of the wheel, is furnished with 5 or 6 cams placed at different situations round the shaft, so as to act in succession on the projecting teeth of the upright rods or pestles. Each of these weighs 200 pounds, and works in a corresponding oblong mortar of stone or wood.

The *patio*, or amalgamation floor, *fig.* 1004, is a large flat space, open to the sky, 312 feet in length, by 236 in breadth, and securely surrounded by strong walls. It is paved with large unhewn blocks of porphyry, and is capable of containing 24 *tortas*, or flat circular collections of *lama*, of about 50 feet diameter, and 7 inches deep, when the patio is not filled, (but of somewhat smaller dimensions when nearly so,) ranged in 4 rows, and numbered from the left-hand corner. At one end a small space is generally set apart for the assays, which are made each on one monton.

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The following description of Mexican amalgamation is given by Captain Lyon.

A torta of Zacatecas contains 60 montons of 20 quintals each, and is thus formed: — In the first instance, a square space, of the requisite size for a torta, is marked out, and enclosed by a number of rough planks, which are propped in their places on the patio floor by large stones, and dried horse-dung and dust are piled round their edges to prevent the escape of the lama. A heap of saltierra (salt mixed with earthy impurities) is then piled in the centre, in the proportion of 2 fanegas (each = 1·6 English bushels) and a half to the monton, = 150 for the torta. After this, the lama, or ore ground into a fine paste, is poured in. When the last or 60th monton is delivered, the saltiera is shovelled down and well mixed with the lama, by treading it with horses, and turning it with shovels; after which the preparation is left at rest for the remainder of the day. On the following day comes the *el incorporo*. After about one hour's treading by horses, the magistral or roasted and pulverized copper ore is mixed with the lama, (the *repaso* or treading-mill still continuing,) in the proportion of 15 cargas of 12 arrobas (25 lbs. each) to the torta, if the ore be of 6 marcs to the monton, and in winter in only half the quantity. For it is a singular fact, that in summer the mixture cools, and requires more warmth; while in winter it acquires of itself additional heat. With poorer ores, as for instance those of 4 marcs to the monton, 12 cargas are applied in summer, and 6 in winter. From November to February, lime is also occasionally used to cool the lama, in the proportion of about a peck per monton.

The *repaso*, or treading out, is continued by six horses, which are guided by one man, who stands in the lama, and directs them all by holding all their long halters. This operation is much more effectual in a morning than an evening, and occupies about five or six hours. When the magistral is well mixed, the quicksilver is applied by being sprinkled through pieces of coarse cloth doubled up like a bag, so that it spurts out in very minute particles. The second treading of the horses then follows; after which the whole mixture is turned over by six men with wooden shovels, who perform the operation in an hour. The torta is then smoothed and left at rest for one entire day, to allow the incorporation to take place. It undergoes the turning by shovels and treading by horses every other day, until the amalgamator ascertains that the first admixture of quicksilver is found to be all taken up by the silver; and this he does by vanning or washing a small quantity of the torta in a little bowl. A new supply is then added, and when this has done its duty, another is applied to catch any stray particles of silver. On the same day, after a good repaso, the torta is removed on hand-barrows by the laborers, to the *lavaderos*, in order that it may receive its final cleansing. The general method of proportioning the quicksilver to the tortas, is by allowing that every marco of silver which is promised by trial of the ores as the probable produce of a monton, will require in the whole process 4 lbs.

In metals of five to six marcs and a half per monton (of the average richness of Zacatecas), 16 lbs. of quicksilver were incorporated for every monton, = 900 lbs. for the torta. On the day of the second addition, the proportion is 5 lbs. the monton; and when the torta is ready to receive the last dose of quicksilver, it is applied at the rate of 7 lbs. the monton, = 420 lbs.; making a total of 1620 lbs. of quicksilver. With poorer ores, less quicksilver and less magistral are required.

The usual time for the completion of the process of amalgamation, is from 12 to 15 days in the summer, and 20 to 25 in the winter. This is less than a third of the time taken at some other mines in Mexico. This rapidity is owing to the tortas being spread very flat, and receiving thereby the stronger influence of the sun. In the Mexican mines, only one monton is commonly mixed at a time; and the lama is then piled in a small conical heap or monton.

Lavadero, or washing vat.—Here the prepared tortas are washed, in order to carry off the earthy matters, and favor the deposition of the amalgam at the bottom. Each vat is about 8 feet deep, and 9 in diameter; and solidly built in masonry.

A large horizontal wheel, worked by mules, drives a vertical one, which turns a horizontal wheel fitted round a perpendicular wooden shaft, revolving upon an iron pivot at the bottom of the vat. To the lower end of this shaft, four cross-beams are fitted, from which long wooden teeth rise to the height of 5 feet. Their motion through the water being rapid, keeps all the lighter particles afloat, while the heavier sink to the bottom. The large wheel is worked by four mules, two at each extremity of the cross-beam. Water is supplied from an elevated tank. It requires 12 hours' work of one tub to wash a torta. Eight porters are employed in carrying the prepared *lama* of the torta in hand-barrows to the vats. The earthy matter receives a second washing.

The amalgam is carried in bowls into the *azogueria*, where it is subjected to straining through the strong canvass bottom of a leather bag. The hard mass left in the bag is moulded into wedge-shaped masses of 30 lbs., which are arranged in the burning-house, (*fig.* 1005), to the number of 11, upon a solid copper stand, called *baso*, having a round hole in its centre. Over this row of wedges several others are built; and the whole pile is called *pina*. Each circular range is firmly bound round with a rope. The base is placed over a pipe which leads to a small tank of water for condensing the quicksilver; a cylindrical space being left in the middle of the *pina*, to give free egress to the mercurial vapors.

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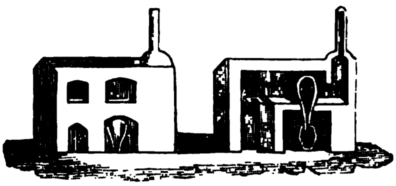

A large bell-shaped cover, called *capellina*, is now hoisted up, and carefully lowered over the *pina*, by means of pulleys. A strong lute of ashes, saltierra, and lama is applied to its lower edge, and made to fit very closely to the plate on which the base stands. A wall of fire-bricks is then built loosely round the capellina, and this space is filled with burning charcoal, which is thrice replenished, to keep it burning all night. After the heat has been applied 20 hours, the bricks and ashes are removed, the luting broken, and the capellina hoisted up. The burned silver is then found in a hard mass, which is broken up, weighed, and carried to the casting-house, to be formed into bars of about 1080 ounces each. The loss of silver in burning is about 5 ounces to each bar (*barra*), and the loss of quicksilver, from 2½ upon the good metals, to 9 upon the coarse.

Molina told Mr. Miers, that the produce of the galena ores of Uspaltata did not average more than 2 marcs per *caxon* of 5000 lbs., which is an excessively poor ore. The argentiferous galena ores of Cumberland afford 11 marcs per caxon; while the average produce of the Potosi silver ores is only 5 or 6 marcs in the same quantity. These comparisons afford the clearest evidence that the English mode of smelting can never be brought into com petition with the process of amalgamation as practised in America.

Humboldt, Gay Lussac, Boussingault, Karsten, and several other chemists of note, have offered solutions of the amalgamation enigma of Mexico and Peru. The following seems to be the most probable *rationale* of the successive steps of the process:—

The addition of the *magistral* (powder of the roasted copper pyrites), is not for the purpose of disengaging muriatic acid from the sea salt (*saltierra*), as has been supposed, since nothing of the kind actually takes place; but, by reciprocal or compound affinity, is serves to form chloride of copper, and chloride of iron, upon the one hand, and sulphate of soda, upon the other. Were sulphuric acid to be used instead of the magistral, as certain novices have prescribed, it would certainly prove injurious, by causing muriatic acid to exhale. Since the ores contain only at times oxyde of silver, but always a great abundance of oxyde of iron, the acid would carry off both partly, but leave the chloride of silver in a freer state. A magistral, such as sulphate of iron, which is not in a condition to generate the chlorides, will not suit the present purpose; only such metallic sulphates are useful as are ready to be transformed into chlorides by the *saltierra*. This is peculiarly the case with sulphate of copper. Its deuto-chloride gives up chlorine to the silver, becomes in consequence a protochloride, while the chloride of silver, thus formed, is revived, and amalgamated with the quicksilver present, by electro-chemical agency which is excited by the saline menstruum; just as the voltaic pile of copper and silver is rendered active by a solution of sea salt. A portion of chloride of mercury will be simultaneously formed, to be decomposed in its turn by the sulphate of silver resulting from the mutual action of the acidified pyrites, and the silver or its oxyde in the ore. An addition of quicklime counteracts the injurious effect of too much magistral, by decomposing the resulting sulphate of copper. Quicksilver being an excellent conductor of heat, when introduced in too great quantities, is apt to cool the mass too much, and thereby enfeebles the operation of the deuto-chloride of copper upon the silver.

There is a method of extracting silver from its ores by what is called *imbibition*. This is exceedingly simple, consisting in depriving, as far as possible, the silver of its gangue, then melting it with about its own weight of lead. The alloy thus procured, contains from 30 to 35 *per cent.* of silver, which is separated by cupellation on the great scale, as described under ores of *lead*. In this way the silver is obtained at Kongsberg in Norway.

The amalgamation works at Halsbrücke, near Freyberg, for the treatment of silver ores by mercury, have been justly admired as a model of arrangement, convenience, and regularity; and I shall conclude this subject with a sketch of their general distribution.

Fig. 1006 presents a vertical section of this great *usine* or *hüttenwerk*, subdivided into four main departments. The first, A, B, is devoted to the preparation and roasting of the matters intended for amalgamation. The second, B, C, is occupied with two successive

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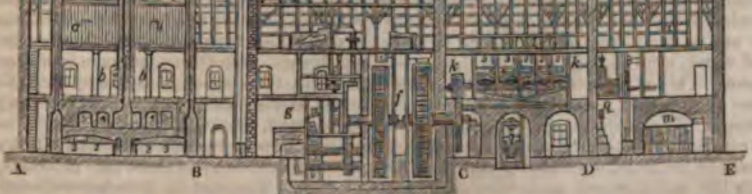


siftings and the milling. The third, C, D, includes the amalgamation apartment above, and the wash-house of the residuum below. And in the fourth, D, E, the distilling apparatus is placed, where the amalgam is finally delivered.

Thus, from one extremity of this building to the other, the workshops follow in the order of the processes; and the whole, over a length of 180 feet, seems to be a natural laboratory, through which the materials pass, as it were of themselves, from their crude to their refined condition; so skilfully economized and methodical are the labors of the workmen; such are the regularity, precision, concert, and facility, which pervade this long series of combinations, carriages, movements, and metamorphoses of matter.

Here we distinguish the following objects:—

1. In division A, B; *a*, *a*, is the magazine of salt; *b*, *b*, is the hall of preparation of the ores; on the floor of which they are sorted, interstratified, and mixed up with salt; *c*, *c*, are the roasting furnaces; in each of which we see, 1, the fireplace; 2, 3, the reverberatory hearth, divided into two portions, one a little higher than the other, and more distant from the fireplace, called the *drier*. The materials to be calcined fall into it, through a chimney 6. The other part 2, of the hearth, is the calcining area. Above the furnace are chambers of sublimation 4, 5, for condensing some volatile matters which escape by the opening 7. *e* is the main chimney.

2. In the division B, C, we have *d*, the floor for the coarse sifting; beneath, that for the fine sieves; from which the matters fall into the hopper, whence they pass down to *g*, the mill-house, in which they are ground to flour, exactly as in a corn-mill, and are afterwards bolted through sieves. *p*, *f*, is the wheel machinery of the mill.

3. The compartment C, D, is the amalgamation work, properly speaking, where the casks are seen in their places. The washing of the residuums is effected in the shop *l*, below. *k*, *k*, is the compartment of revolving casks.

4. In the division D, E, the distillation process is carried on. There are four similar furnaces, represented in different states, for the sake of illustration. The wooden drawer is seen below, supporting the cast-iron basin, in which the tripod with its candelabra for bearing the amalgam saucers is placed. *q* is a store chamber.

At B, are placed the pulleys and windlass for raising the roasted ore, to be sifted and ground; as also for raising the milled flour, to be transported to the amalgamation casks. At D, the crane stands for raising the iron bells that cover the amalgamation candelabra.

Details of the Amalgamation Process, as practised at Halsbrücke. — All ores which contain more than 7 lbs. of lead, or 1 lb. of copper, per cent., are excluded from this reviving operation (*anquickverfahren*); because the lead would render the amalgam very impure, and the copper would be wasted. They are sorted for the amalgamation, in such a way that the mixture of the poorer and richer ores may contain 7½, or, at most, 8 loths (of ½ oz. each) of silver per 100 lbs. The most usual constituents of the ores are, sulphur, silver, antimonial silver (speissglanzsilber), bismuth, sulphurets of arsenic, of copper, iron, lead (nickel, cobalt), zinc, with several earthy minerals. It is essential that the ores to be amalgamated shall contain a certain proportion of sulphur, in order that they may decompose enough of sea salt in the roasting to disengage as much chlorine as to convert all the silver present into a chloride. With this view, ores poor in sulphur are mixed with those that are richer, to make up a determinate average. The ore-post is laid upon the *bed-floor*, in a rectangular heap, about 17 ells long, and 4½ ells broad (13 yards and 3½); and upon that layer the requisite quantity of salt is let down from the floor above, through a wooden tunnel; 40 cwts. of salt being allotted to 400 cwts. of ore. The heap being made up with alternate strata to the desired magnitude, must be then well mixed, and formed into small bings, called *roast-posts*, weighing each from 3½ to 4½ cwts. The annual consumption of salt at Halsbrücke is 6000 cwts.; it is supplied by the Prussian salt-works.

Roasting of the Amalgamation Ores.— The furnaces appropriated to the roasting of the ore-posts are of the reverberatory class, provided with soot chambers. They are built up alongside of the *bed-floor*, and connected with it by a brick tunnel. The prepared ground ore (*erzmehl*) is spread out upon the hearth, and dried with incessant turning over; then the fire is raised so as to kindle the sulphur, and keep the ore redhot for one or two hours; during which time, dense white-gray vapors of arsenic, antimony, and water, are exhaled. The desulphuration next begins, with the appearance of a blue flame. This continues for three hours, during which the ignition is kept up; and the mass is diligently turned over, in order to present new surfaces, and to prevent any caking. Whenever sulphurous acid ceases to be formed, the finishing calcination is to be commenced with increased firing; the object being now to decompose the sea salt by means of the metallic sulphates that have been generated, to convert them into chlorides, with the simultaneous production of sulphate of soda. The stirring is to be continued till the proofs taken from the hearth no longer betray the smell of sulphurous, but only of muriatic acid gas. This roasting stage lasts commonly three quarters of an hour, 13 or 14 furnaces are worked at the same time at Halsbrücke; and each turns out in a ek 5 tons upon an average. Out of the *nicht* chambers or soot vaults of the furnaces, om 96 to 100 cwts. of ore-dust are obtained, containing 32 marcs (16 lbs.) of silver. is dust is to be treated like unroasted ore. The fuel of the first fire is pitcoal; of the ishing one, fir-wood. Of the former 115½ cubic feet, and of the latter, 294¼, are, upon average, consumed for every 100 cwts. of ore.

During the last roasting, the ore increases in bulk by one fourth, becomes in conse- ence a lighter powder, and of a brown color. When this process is completed, the ore raked out upon the stone pavement, allowed to cool, then screened in close sieve-boxes, order to separate the finer powder from the lumps. These are to be bruised, mixed th sea salt, and subjected to another calcination. The finer powder alone is taken to e millstones, of which there are 14 pairs in the establishment. The stones are of gra- te, and make from 100 to 120 revolutions per minute. The roasted ore, after it has ssed through the bolter of the mill, must be as impalpable as the finest flour.

The Amalgamation.—This (the *verquicken*) is performed in 20 horizontal casks, ranged in 4 rows, each turning upon a shaft which passes through its axis; and all iven by the water-wheel shown in the middle of *fig.* 1006. The casks are 2 feet 10 ches long, 2 feet 8 inches wide, inside measure, and are provided with iron ends. The ves are 3½ inches thick, and are bound together with iron hoops. They have a double ng-hole, one formed within the other, secured by an iron plug fastened with screws. ey are filled by means of a wooden spout terminated by a canvass hose; through ich 10 cwts. of the bolted ore-flour (*erzmehl*) are introduced after 3 cwts. of water ve been poured in. To this mixture, from ¾ to ⅛ of a cwt. of pieces of iron, 1½ inch uare, and ⅜ thick, are added. When these pieces get dissolved, they are replaced by ers from time to time. The casks being two thirds full, are set to revolve for 1½ or hours, till the ore-powder and water become a uniform pap; when 5 cwts. of quick- ver are poured into each of them. The casks being again made tight, are put in gear th the driving machinery, and kept constantly revolving for 14 or 16 hours, at the rate 20 or 22 turns in the minute. During this time they are twice stopped and opened, in ler to see whether the pap be of the proper consistence; for if too thick, the globules quicksilver do not readily combine with the particles of ore; and if too thin, they l and rest at the bottom. In the first case, some water must be added; in the second, ne ore. During the rotation, the temperature rises, so that even in winter it some- es stands so high as 104° F.

The chemical changes which occur in the casks are the following:—The metallic lorides present in the roasted ore are decomposed by the iron, whence results muriate iron, whilst the deutochloride of copper is reduced partly to protochloride, and partly metallic copper, which throw down metallic silver. The mercury dissolves the silver, pper, lead, antimony, into a complex amalgam. If the iron is not present in sufficient antity, or if it has not been worked with the ore long enough to convert the copper utochloride into a protochloride, previously to the addition of the mercury, more or less the last metal will be wasted by its conversion into protochloride (calomel.) The ter holds in solution sulphate of soda, undecomposed sea salt, with chlorides of iron, nganese, &c.

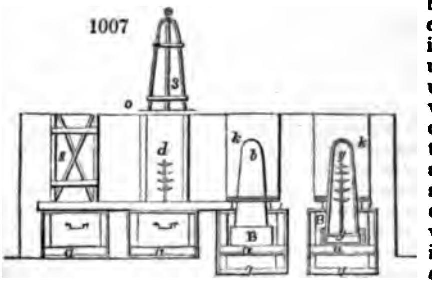
As soon as the revivification is complete, the casks must be filled with water, set to volve slowly (about 6 or 8 times in the minute), whereby in the course of an hour, or hour and a half at most, a great part of the amalgam will have collected at the bot- a; and in consequence of the dilution, the portion of horn silver held in solution the sea salt will fall down and be decomposed. Into the small plug in the centre of bung, a small tube with a stopcock is now to be inserted, to discharge the amalgam o its appropriate chamber. The cock must be stopped whenever the brown muddy iduum begins to flow. The main bung being then opened, the remaining contents the casks are emptied into the *wash-tun*, while the pieces of iron are kept back. e residuary ore is found to be stripped of its silver within $\frac{5}{32}$ or $\frac{7}{40}$ of an ounce per t. The emptying of all the casks, and charging them again, takes 2 hours; and the ole process is finished within 18 or 20 hours; namely, 1 hour for charging, 14 to 16 rs for amalgamating, 1½ hour for diluting, 1 hour for emptying. In 14 days, 3200 ts. of ore are amalgamated. For working 100 cwts. of ore, 14½ lbs. of iron, and 2 . 12½ ounces of mercury are required; whence, for every pound of silver obtained, 5 of an ounce of mercury are consumed.

Trials have been made to conduct the amalgamation process in iron casks, heated to ° or 160° Fahrenheit, over a fire; but, though the de-silvering was more complete, loss by mercury was so much greater as to more than counterbalance that advantage.

Treatment of the Amalgam.—It is first received in a moist canvass bag, through ich the thin uncombined quicksilver spontaneously passes. The bag is then tied up l subjected to pressure. Out of 20 casks, from 3 to 3½ cwts. of solid amalgam are thus cured, which usually consist of 1 part of an alloy, containing silver of 12 or 13 *loths* 16), and 6 parts of quicksilver. The foreign metals in that alloy are, copper, lead, gold, antimony, cobalt, nickel, bismuth, zinc, arsenic, and iron. The filtered quicksilver contains moreover 2 to 3 loths of silver in the cwt.

Fig. 1007 represents the apparatus for distilling the amalgam in the Halsbrücke works; marked *m* in *fig.* 1006. *a* is the wooden drawer, sliding in grooves upon the basis *q*; B is an open basin or box of cast iron, laid in the wooden drawer; *y* is a kind of iron candelabra, supported upon four feet, and set in the basin B; under *d* are five dishes, or plates of wrought iron, with a hole in the centre of each, whereby they are fitted upon the stem of the candelabra, 3 inches apart, each plate being successively smaller than the one below it. 3 indicates a cast-iron bell, furnished with a wrought-iron frame and hook, for raising it by means of a pulley and cord. *s* is a sheet-iron door for closing the stove, whenever the bell has been set in its place.

1007



The box *a*, and the basin B above it, are filled with water, which must be continually renewed, through a pipe in the side of the wooden box, so that the iron basin may be kept always submersed and cool. The drawer *a*, being properly placed, and the plates under *d* being charged with balls of amalgam (weighing altogether 3 cwts.), the bell 3 is to be let down into the water, as at *y*, and rested upon the lower part of the candelabra. Upon the ledge 1, which defines the bottom of the fire-place, a circular plate of iron is laid, having a hole in its middle for the bell to pass through. Upon this plate chips of fir-wood are kindled, then the door *s*, which is lined with clay, is closed and luted tight. The fuel is now placed in the vacant space *k*, round the upper part of the bell. The fire must be fed in most gradually, first with turf, then with charcoal; whenever the bell gets red, the mercury volatilizes, and condenses in globules into the bottom of the basin B. At the end of 8 hours, should no more drops of mercury be heard to fall into the water, the fire is stopped. When the bell has become cool, it is lifted off; the plates are removed from the candelabra *d*; and this being taken out, the drawer *a* is slid away from the furnace. The mercury is drained, dried, and sent again into the amalgamation works. The silver is fused and refined by cupellation.

The solid amalgam which is distilled in the above apparatus, would be distilled more profitably out of iron trays set in the mercurial retorts described and figured in pages 815, 816.

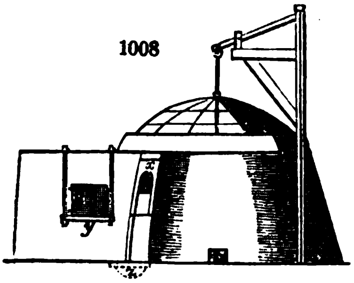
From 3 cwts. of amalgam, distilled under the bell, from 95 to 100 marcs (½ lbs.) of *teller* silver (dish silver) are procured, containing from 10 to 13½ parts of fine silver out of 16; one fifth part of the metal being copper. The *teller* silver is refined in quantities of 160 or 170 marcs, in black-lead crucibles filled within two inches of their brims, and submitted to brisk ignition. The molten mass exhales some vapors, and throws up a liquid slag, which being skimmed off, the surface is to be strewed over with charcoal powder, and covered with a lid. The heat having been briskly urged for a short time, the charcoal is then removed along with any fresh slag that may have risen, in order to observe whether the vapors have ceased. If not, fresh charcoal must be again applied, the crucible must be covered, and the heat increased, till fumes are no longer produced, and the surface of the silver becomes tranquil. Finally, the alloy, which contains a little gold and much copper, being now from 11 to 13 *löthig* (that is, holding from 11 to 13 parts of fine silver in 16 parts), is cast into iron moulds, in ingots of 60 marcs. The loss of weight by evaporation and skimming of the slag amounts to 2 per cent.; the loss in silver is quite inconsiderable.

The dust from the furnace (*tiegelöfen*) is collected in a large condensation chamber of the chimney, and affords from 40 to 50 marcs of silver per cwt. The slags and old crucibles are ground and sent to the small amalgamation mill.

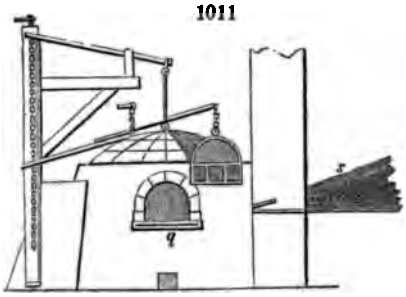
The earthy residuum of the amalgamation casks being submitted to a second amalgamation, affords out of 100 cwts. about 2 lbs. of coarse silver. This is first fused along with three or four per cent. of a mixture of potashes and calcined quicksalz (impure sulphate of soda), and then refined. The supernatant liquor that is drawn out of the tanks in which the contents of the casks are allowed to settle, consists chiefly of sulphate of soda, along with some common salt, sulphates of iron and manganese, and a little phosphate, arseniate, and fluate of soda. The earthy deposite contains from ¼ to $\frac{1}{12}$ of a *loth* of silver per cwt., but no economical method of extracting this small quantity has yet been contrived.

The argentiferous or *rich lead* is treated in Germany by the cupellation furnace represented in *figs.* 1008, 1009, 1010, and 1011. These figures exhibit the cupellation furnace of the principal smelting works in the Hartz, where the following parts must be distinguished; (*fig.* 1010); 1. masonry of the foundation; 2. flues for the escape of moisture; 3. stone covers of the flues; 4. bed of hard rammed scoriæ; 5. bricks set on edge, to form the permanent area of the furnace; 6. the sole, formed of wood ashes, washed, dried, and beaten down; *k*, dome of iron plate, moveable by a crane, and susceptible of being lined two inches thick with loam; *n*, *n*, tuyères for two bellows *s*; having valves suspended before their orifices to break and spread the blast; *q*, door for introducing into the furnace the charge of lead, equal to 84 quintals at a time; *s*, *fig.* 1011, two bellows, like those of a smith's forge; *y*, door of the fireplace, through which billets of wood are thrown on the grate; *x*, small aperture or door, for giving issue to the frothy scum of the cupellation, and the litharge; *z*, basin of safety, usually covered with a stone slab, over which the litharge falls; in case of accident the basin is laid open to admit the *rich lead*.

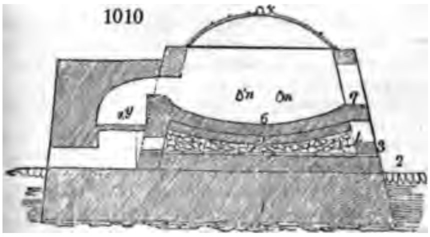
1008



1011

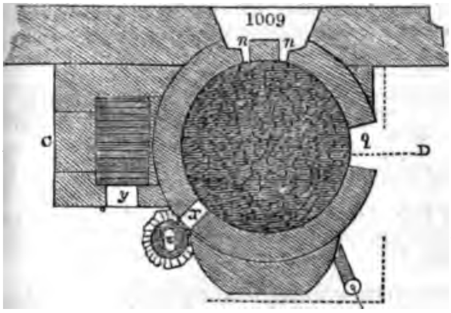


1010



The following is the mode of conducting the cupellation. Before putting the lead into the furnace, a floor is made in it of ashes beat carefully down (see 6, *fig.* 1010); and there is left in the centre of this floor a circular space, somewhat lower than the rest of the hearth, where the silver ought to gather at the end of the operation. The cupel is fully six feet in diameter.

1009



In forming the floor of a cupel, 35 cubic feet of washed wood ashes, usually got from the soap works, are employed. The preparation of the floor requires two and a half hours' work; and when it is completed, and the moveable dome of iron plate has been lined with loam, 84 quintals (cwts.) of lead are laid on the floor, 42 quintals being placed in the part of the furnace farthest from the bellows, and 42 near to the fire-bridge; to these, scoriæ containing lead and silver are added, in order to lose nothing. The moveable lid is now luted on the furnace, and heat is slowly applied in the fireplace, by burning fagots of fir-wood, which is gradually raised. Section 1010 is in the line C, D, of 1009.

At the end of three hours, the whole lead being melted, the instant is watched for when no more ebullition can be perceived on the surface of the bath or melted metal; then, but not sooner, the bellows are set a playing on the surface at the rate of 4 or 5 strokes per minute, to favor the oxydizement.

In five hours, reckoned from the commencement of the process, the fire is smartly raised; when a grayish froth (*abstrich*) is made to issue from the small aperture *x* of the furnace. This is found to be a brittle mixture of oxydized metals and impurities. The workman now glides the rake over the surface of the bath, so as to draw the froth out of the furnace; and, as it issues, powdered charcoal is strewed upon it, at the aperture *x*, to cause its coagulation. The froth skimming lasts for about an hour and a half.

After this time, the litharge begins to form, and it is also let off by the small opening *x*; its issue being aided by a hook. In proportion as the floor of the furnace gets impregnated with litharge, the workman digs in it a gutter for the escape of the liquid litharge; it falls in front of the small aperture, and concretes in stalactitic forms.

By means of the two moveable valves suspended before the tuyères *n*, *n*, (*fig.* 1010), the workman can direct the blast as he will over the surface of the metal. The wind should be made to cause a slight curl on the liquid, so as to produce circular undulations, and gradually propel a portion of the litharge generated towards the edges of the cupel, and allow this to retain its shape till the end of the operation. The stream of air should drive the greater part of the litharge towards the small opening *x*, where the workman deepens the outlet for it, in proportion as the level of the metal bath descends, and the bottom of the floor rises by the apposition of the litharge formed. Litharge is thus obtained during about 12 hours; after which period the cake of silver begins to take shape in the centre of the cupel.

Towards the end of the operation, when no more than four additional quintals of litharge can be looked for, and when it forms solely in the neighborhood of the silver cake in the middle of the floor, great care must be taken to set apart the latter portions, because they contain silver. About this period, the fire is increased, and the workman places before the little opening *x* a brick, to serve as a mound to the efflux of litharge. The use of this brick is,—1. to hinder the escape of the silver in case of any accident: for example, should an explosion take place in the furnace; 2. to reserve a magazine of litharge, should that still circulating round the silver cake be suddenly absorbed by the cupel, for in this dilemma the litharge must be raked back on the silver; 3. to prevent the escape of the water that must be thrown on the silver at the end of the process.

When the argentiferous litharge, collected in the above small magazine, is to be removed, it is let out in the form of a jet, by the dexterous use of the iron hook.

Lastly, after 20 hours, the silver cake is seen to be well formed, and nearly circular. The moment for stopping the fire and the bellows is indicated by the sudden disappearance of the colored particles of oxyde of lead, which, in the latter moments of oxydation, undulate with extreme rapidity over the slightly convex surface of the silver bath, moving from the centre to the circumference. The phenomenon of their total disappearance is called the *lightning*, or fulguration. Whenever this occurs, the plate of silver being perfectly clean, there is introduced into the furnace, by the door *q*, a wooden spout, along which water, previously heated, is carefully poured on the silver.

The cupellation of 84 quintals of argentiferous lead takes in general 18 or 20 hours' working. The promptitude of the operation depends on the degree of purity of the leads employed, and on the address of the operator, with whom also lies the economy of fuel. A good workman completes the cupellation of 84 quintals with 300 billets, each equivalent to a cubic foot and eight tenths of wood (Hartz measure); others consume 400 billets, or more. In general, the cupellation of 100 quintals of lead, executed at the rate of 84 quintal charges, occasions a consumption of 790 cubic feet of resinous wood billets.

The products of the charge are as follows:—

1. Silver, holding in 100 marcs, 7 marcs and 3 loths of alloy -	24 to 30 marcs.
2. Pure litharge, containing from 88 to 90 per cent. of lead -	50 - 60 quintals.
3. Impure litharge, holding a little silver - - -	2 - 6 —
4. Skimmings of the cupellation - - - -	4 - 8 —
5. Floor of the furnace impregnated with litharge - -	22 - 30 —

NOTE.—*The marc is* 7 *oz.* 2 *dwts.* 4 *gr. English troy; and the loth is half an ounce.* 16 *loths make a marc.* 100 *pounds Cologne are equal to* 103 *pounds avoirdupois; and the above quintal contains* 116 *Cologne pounds.*

The loss of lead inevitable by this operation, is estimated at 4 parts in 100. It has been diminished as much as possible in the Frankenscharn works of the Hartz, by leading the smoke into long flues, where the lead fumes are condensed into a metallic soot. The silver cake receives a final purification at the Mint, in a cupel on a smaller scale.

From numerous experiments in the great way, it has been found that not more than 100 quintals of lead can be profitably cupelled at one operation, however large the furnace, and however powerful and multiplied the bellows and tuyères may be; for the loss on either the lead or the silver, or on both, would be increased. In one attempt, no less than 500 quintals were acted on, in a furnace with two fireplaces, and four escapes for the litharge; but the silver remained disseminated through the lead, and the *lightning* could not be brought on. The chief object in view was economy of fuel.

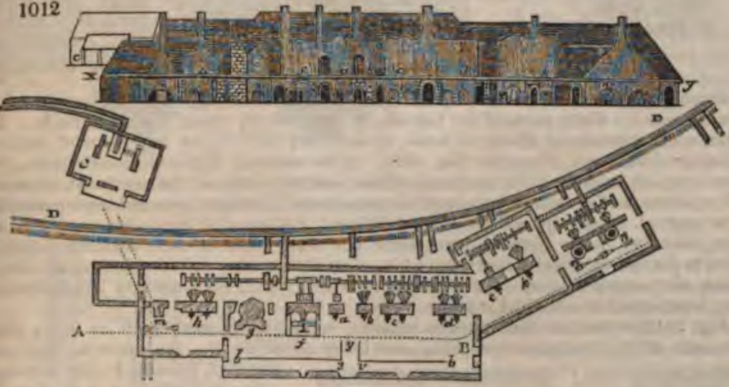
Reduction of the Litharge.—This is executed in a slag-hearth, with the aid of wood charcoal.

Such is the train of operations by which the cupriferous galena *schlich*, or ground ore is reduced, in the district of Clausthal, into lead, copper, and silver. The works of Frankenscharn have a front fully 400 feet long.

Fig. 1011, exhibits the plan and elevation of these smelting-works, near Clausthal, in the Hartz, for lead ores containing copper and silver, where about 84,000 cwts. of *schlich* (each of 123 Cologne pounds) are treated every year. This quantity is the produce of thirty distinct mines, as also of nearly as many stamp and preparation works. All these different *schlichs*, which belong to so many different joint-stock companies, are confounded and worked up together in the same series of metallurgic operations; the resulting mixture being considered as one and the same ore belonging to a single undertaking; but in virtue of the order which prevails in this royal establishment, the rights of each of the companies, and consequently of each shareholder, are equitably regulated. A vigorous control is exercised between the mines and the stamps, as also between the stamps and the smelting-houses; while the cost of the metallurgic operations is placed under the officers of the crown, and distributed, upon just principles, among the several mines, according to the quantities of metal furnished by each.

Silver-smelting Works of Frankenscharn, near Clausthal.

1012



From these arrangements, the following important advantages flow :—

1. The poor ores may be smelted with profit, without putting the companies to any risk or expense in the erection of new works; 2, by the mixture of many different ores, the smelting and metallic product become more easy and abundant; 3, the train of the operations is conducted with all the lights and resources of science; and 4, the amount of metal brought into the market is not subject to such fluctuations as might prove injurious to their sale.

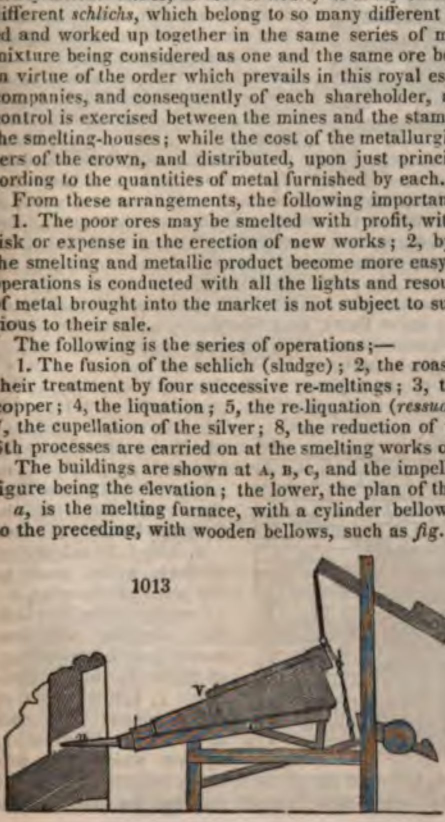
The following is the series of operations ;—

1. The fusion of the schlich (sludge) ; 2, the roasting of the mattes under a shed, and their treatment by four successive re-meltings ; 3, the treatment of the resulting black copper; 4, the liquation ; 5, the re-liquation (*ressuage*) ; 6, the refining of the copper ; 7, the cupellation of the silver; 8, the reduction of the litharge into lead. The 5th and 6th processes are carried on at the smelting works of Altenau.

The buildings are shown at A, B, C, and the impelling stream of water at D; the upper figure being the elevation ; the lower, the plan of the works.

a, is the melting furnace, with a cylinder bellows behind it; *b*, *c*, *d*, furnaces similar to the preceding, with wooden bellows, such as *fig.* 1013; *e*, is a furnace for the same purpose, with three tuyères, and a cylinder bellows; *f*, the large furnace of fusion, also with three tuyères; *g*, a furnace with seven tuyères, now seldom used; *h*, low furnaces, like the English slag-hearths, (*krummofen*,) employed for working the last *mattes* ; *k*, slag-hearths for reducing the litharge; *m*, the area of the liquation ; *n*, *p*, cupellation furnaces.

1013



x, *y*, a floor which separates the principal smelting-house into two stories; the materials destined for charging the furnaces being deposited in beds upon the upper floor, to which they are carried by means of two inclined planes, temeed in front of the range of buildings.

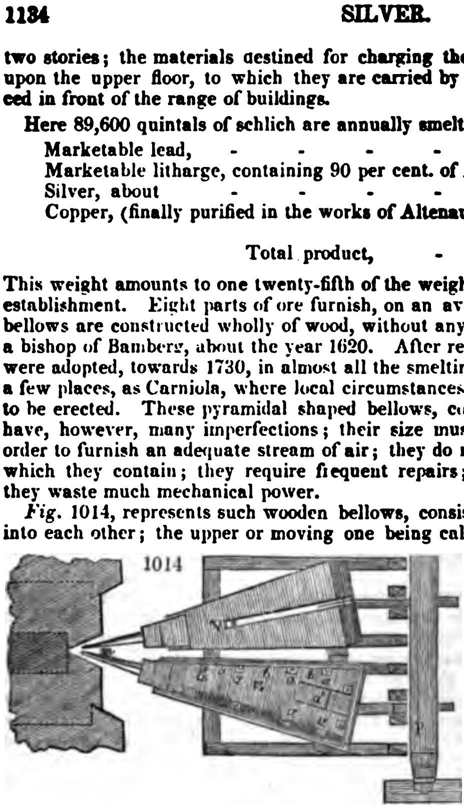
Here 89,600 quintals of schlich are annually smelted, which furnish—

Marketable lead, - - - - - - -	20,907 quintals.
Marketable litharge, containing 90 per cent. of lead, -	7,555
Silver, about - - - - - - -	67
Copper, (finally purified in the works of Altenau,) -	35
Total product, - - -	28,564

This weight amounts to one twenty-fifth of the weight of ore raised for the service of the establishment. Eight parts of ore furnish, on an average, about one of schlich. The bellows are constructed wholly of wood, without any leather; an improvement made by a bishop of Bamberg, about the year 1620. After receiving different modifications, they were adopted, towards 1730, in almost all the smelting-works of the continent, except in a few places, as Carniola, where local circumstances permitted a water blowing-machine to be erected. These pyramidal shaped bellows, composed of moveable wooden boxes, have, however, many imperfections; their size must often be inconveniently large, in order to furnish an adequate stream of air; they do not drive into the furnace all the air which they contain; they require frequent repairs; and, working with great friction, they waste much mechanical power.

Fig. 1014, represents such wooden bellows, consisting of two chests or boxes fitted into each other; the upper or moving one being called the *fly*, the lower or fixed one, the *seat*, (*gite.*) In the bottom of the *gite*, there is an orifice furnished with a clack-valve *d*, opening inwards when the *fly* is raised, and shutting when it falls. In order that the air included in the capacity of the two chests may have no other outlet than the nose-pipe m, the upper portion of the *gite* is provided at its four sides with small square slips of wood, *c*, *c*, *c*, which are pressed against the sides of the *fly* by strong springs of iron wire, *b*, *b*, *b*, while they are retained upon the *gite* by means of small square pieces of wood, a, *a*, *a*, *a*. The latter *a*, *a*, are perforated in the centre, and adjusted upon rectangular stems, called *buchettes;* they are attached, at their lower ends, to the upright sides of the *gite* G. P, is the driving-shaft of a water-wheel, which, by means of cams or tappets, depresses the fly, while the counterweight Q, *fig.* 1013, raises it again.

1014

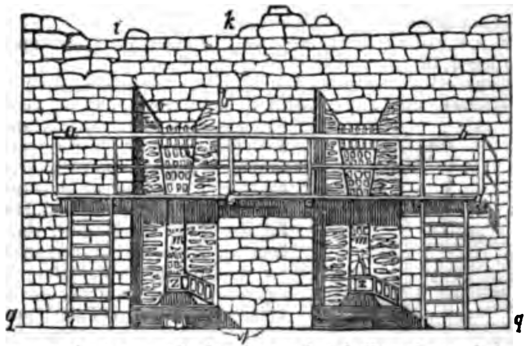


Figs. 1015, 1016, 1017, 1018, represent the moderately high (*demihauts*, or *half-blast*) furnaces employed in the works of the lower Hartz, near Goslar, for smelting the silvery lead ores extracted from the mine of Rammelsberg. See its section in *fig.* 737.

Fig. 1015, is the front elevation of the twin furnaces, built in one body of masonry; *fig.* 1016, is a plan taken at the level of the tuyères, in the line v, *l*, 6, of *fig.* 1017; *figs.* 1017 and 1018, exhibit two vertical sections; the former in the line A, B, the latter in the line C, D, of *fig.* 1016. In these four figures the following objects may be distinguished.

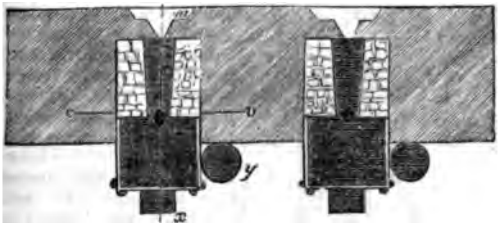
A, *b*, *c*, *d*, a balcony or platform which leads to the place of charging, B; *e*, *f*, wooden stairs, by which the charging workmen mount from the ground *p*, *q*, of the works, to the platform; *g*, *h*, brick-work of the furnaces; *i*, *k*, wall of the smelting-works, against which they are supported; *l*, upper basin of reception, hollowed out of the *brasque*, (or ground charcoal bed,) 6; *m*, arch of the tuyère v, by which each furnace receives the blast of two

1015



bellows; *n*, place of charging, which takes place through the upper orifice *n*, *o*, of the basin *n*, *o*, v, *t*, of the furnace; *t*, a slab of clay, placed in such a way that, during the treatment of the lead, a little metallic zinc may run together in a sloping gutter, seen in *fig.* 1001, formed of slates cemented together with clay.

A 1016

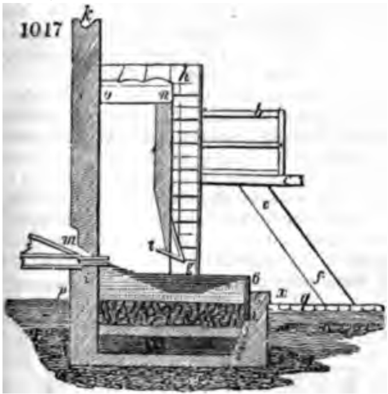


B

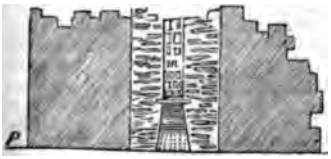
In *figs.* 1015 and 1017, 1, *z*, is the brick-work of the foundations; *m*, conduits (called evaporatory) for the exhalation of the moisture; 4, a layer of slags, rammed above; 5, a bed of clay, rammed above the slags; 6, a brasque, composed of one part of clay, and two parts of ground charcoal, which forms the sole of the furnace.

The excellent refinery furnace, or *treibheerd*, of Frederickshütte, near Tarnowitz, in Upper Silesia, is represented in *figs.* 1019 and 1020. *a*, is the bottom, made of slag or cinders; *b*, the foundation of fire-bricks; *c*, the body of the hearth proper, composed of a mixture of 7 parts of dolomite, and 1 of fire-clay, in bulk; *d*, the grate of the air furnace; *e*, the fire-bridge; *f*, the dome or cap, made of iron plate strengthened with bars, and lined with clay-lute, to protect the metal from burning; *g*, the door of the fireplace; *h*, the ash-pit; *i*, the tap-hole; *k*, *k*, the flue, which is divided by partitions into several channels; *l*, the chimney; *m*, a damper-plate for regulating the draught; *n*, a back valve, for admitting air to cool the furnace, and brushes to sweep the flues; *o*, *tuyère* of copper, which by means of an iron wedge may be sloped more or less towards the hearth; *p*, the *schnepper*, a round piece of sheet iron, hung before the *eye* of the *tuyère*, to break and spread the blast; *q*, the outlet for the glassy litharge.

1017

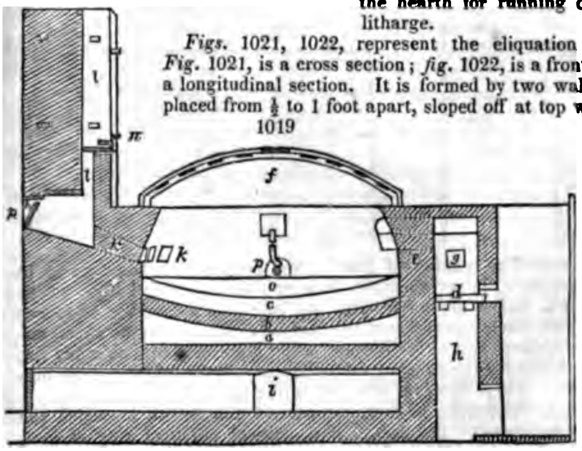


1018

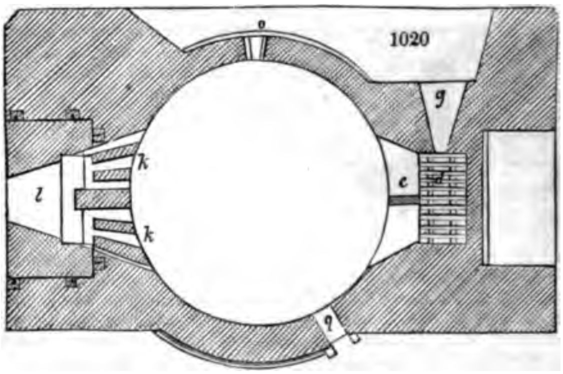


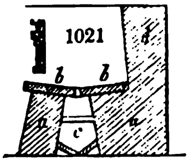
Lime-marl has been found to answer well for making the body of the hearth-sole, as it absorbs the vitrified litharge freely, without combining with it. A basin-shaped hollow is formed in the centre, for receiving the silver at the end of the process; and a gutter is made across the hearth for running off the *glätte* or fluid litharge.

1019



Figs. 1021, 1022, represent the eliquation hearth of Neustadt. *Fig.* 1021, is a cross section; *fig.* 1022, is a front view; and *fig.* 1023, a longitudinal section. It is formed by two walls *a*, *a*, 3½ feet high, placed from ½ to 1 foot apart, sloped off at top with iron plates, three inches thick, and 18 inches broad, called *saigers-charten*, or refining plates, *b*, *b*, inclined three inches towards each other in the middle, so as to leave at the lowest point a slit two and a half inches wide between them, through which the lead, as it sweats out by the heat, is allowed to fall into the space between the two walls c, called the *saigergasse*, (sweating gutter.) The sole of this channel slopes down towards the front, so that the liquefied metal may run off into a crucible or pot. Upon one of the long sides, and each of the shorter ones, of the hearth, the walls *d*, *d*, are raised two feet high, and upon these the liquation lumps rest; upon the other long side, where there is no wall, there is an opening for admitting these lumps into the hearth. The openings are then shut with a sheet or cast iron plate *e*, which, by means of a chain, pulley, and counterweight, may be easily raised and lowered. *f*, is a passage for increasing the draught of air.

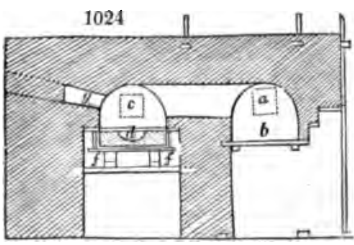

1020


1021

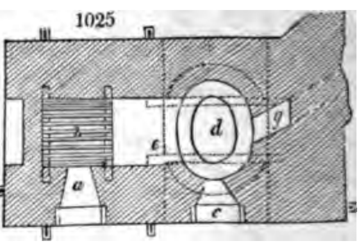
Figs. 1023 and 1026, represent the refining furnaces of Fredrickshütte by Tarnowitz; *a*, is the fire door; *b*, the grate; *c*, the door for introducing the silver; *d*, the moveable test, resting upon a couple of iron rods *e*, *e*, which are let at their ends into the brick-work. They lie lower than would seem to be necessary; but this is done in order to be able to place the surface of the test at any desired level, by placing tiles *f*, *f*, under it; g, the flue, leading to a chimney 18 feet high. For the refining of 100 marks of *blicksilber*, of the fineness of 15½ loths (half ounces) per cwt., 3 cubic feet of pit-coal are required. The test or cupel must be heated before the impure silver and soft lead are put into it.

At these smelting-houses, from 150 to 160 cwts. of very pure *workable lead* (lead containing merely a little silver) are put into the furnace at once, and from 10 to 14 cwts. run off in vitrified oxyde; the remainder is then refined with some pure lead, when an alloy containing from 14½ to 15½ loths of blicksilber per cwt. is obtained.

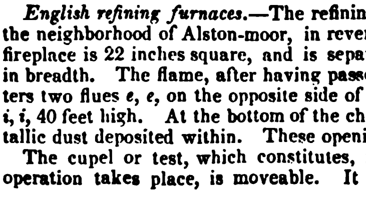
1022



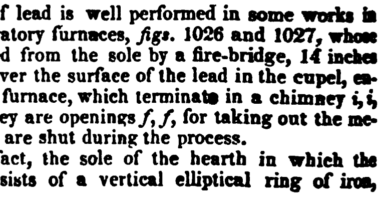
1023



1024



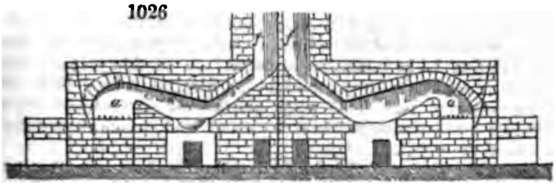
1025



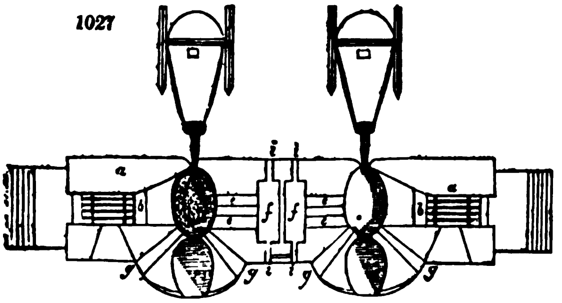
English refining furnaces.—The refining of lead is well performed in some works in the neighborhood of Alston-moor, in reverberatory furnaces, *figs.* 1026 and 1027, whose fireplace is 22 inches square, and is separated from the sole by a fire-bridge, 14 inches in breadth. The flame, after having passed over the surface of the lead in the cupel, enters two flues *e*, *e*, on the opposite side of the furnace, which terminate in a chimney *i*, *i*, *i*, *i*, 40 feet high. At the bottom of the chimney are openings *f*, *f*, for taking out the metallic dust deposited within. These openings are shut during the process.

The cupel or test, which constitutes, in fact, the sole of the hearth in which the operation takes place, is moveable. It consists of a vertical elliptical ring of iron, A, B, C, D, *figs.* 1028 and 1029, 3⅝ inches high, the greatest diameter of the ellipse being 4 feet, and the smallest 2 . Four iron bars (A, D, *m*, *m′*, B, C, *n*, *n′*) are fixed across its bottom, which are also 3⅝ inches broad, and an inch thick. The first of these bars is placed 9 inches from the end of the elliptic ring nearest the fireplace, and the three others are equally distributed between this bar and the back end.

1026

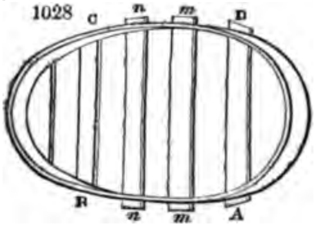


1027

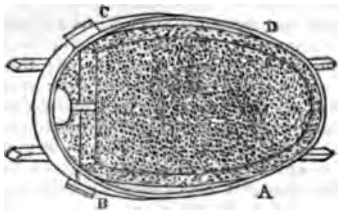


In forming the cupel, several layers of a mixture of moistened bone ashes, and fern ashes, in very fine powder, are put into the *test-frame.* The bone ash constitutes from ⅛ to $\frac{1}{16}$ of the bulk of the mixture, according to the purity of the fern ashes employed, estimated by the proportion of potash they contain, which has the property of semi-vitrifying the powder of burnt bones, of thus removing its friability, and rendering it more durable. The layers of ashes are strongly beat down, till the frame is entirely filled. The mass thus formed is then hollowed out by means of a little spade, made on purpose, till it is only three quarters of an inch thick above the iron bars near the centre of the bottom. A flange, 2 inches broad, is made at the upper part, and 2½ inches at the lower part, except on the front or *breast*, which is 5 inches thick. In this anterior part, there is hollowed out an opening of an inch and a quarter broad, and 6 inches long, with which the outlet or *gateway* of the litharge communicates.

1028



1029



The cupel thus prepared is placed in the refining furnace. It rests in an iron ring built into the brickwork. The arched roof of the furnace is 12 inches above the cupel near the fire-bridge, and 9 inches near the flue at the other end.

The tuyère is placed in the back of the furnace, opposite to the side at which the litharge is allowed to overflow.

Openings *g*, *g*, are left at the sides of each cupel, either for running off or for introducing melted lead.

Refining of lead to extract its silver.—This operation, which the lead of Derbyshire cannot be submitted to with advantage, is performed in a certain number of the smelting-houses at Alston-moor, and always upon leads reduced in the Scotch furnace.

The cupel furnace above described must be slowly heated, in order to dry the cupel without causing it to crack, which would infallibly be produced by sudden evaporation of the moisture in it. When it has been thus slowly brought to the verge of a red heat, it is almost completely filled with lead previously melted in an iron pot. The cupel may be charged with about 5 cwts. At the temperature at which the lead is introduced, it is immediately covered with a gray pellicle of oxyde; but when the heat of the furnace has been progressively raised to the proper pitch, it becomes whitish-red, and has its surface covered over with litharge. Now is the time to set in action the blowing-machine, the blast of which, impelled in the direction of the great axis of the cupel, drives the litharge towards the *breast* of the cupel, and makes it flow out by the way prepared for it, through which it falls upon a cast-iron plate, on a level with the floor of the apartment, and is dispersed into tears. It is carried in this state to the furnace of reduction, and revived. As by the effect of the continual oxydization which it undergoes, the surface of the metal necessarily falls below the level of the gateway of the litharge, melted lead must be added anew by ladling it into the furnace from the iron boiler, as occasion may require. The operation is carried on in this manner till 84 cwts. or 4 Newcastle *fodders* of lead have been introduced, which takes from 16 to 18 hours, if the tuyère has been properly set. The whole quantity of silver which this mass of lead contains, is left in combination with about 1 cwt. of lead, which, under the name of rich lead, is taken out of the cupel.

When a sufficient number of these pieces of rich lead have been procured, so that by their respective quality, as determined by assaying, they contain in whole from 1000 to 2000 ounces of silver, they are re-melted to extract their silver, in the same furnace, but in a cupel which differs from the former in having at its bottom a depression capable of receiving at the end of the process the cake of silver. In this case a portion of the bottom remains uncovered, on which the scoriæ may be pushed aside with a little rake, from the edges of the silver.

The experiments of MM. Lucas and Gay Lussac have proved that fine silver, exposed to the air in a state of fusion, absorbs oxygen gas, and gives it out again in the act of consolidation. The quantity of oxygen thus absorbed may amount to twenty-two times the volume of the silver. The following phenomena are observed when the mass of metal is considerable; for example, from 40 to 50 pounds.

The solidification commences at the edges, and advances towards the centre. The liquid silver, at the moment of its passage to the solid state, experiences a slight agitation, and then becomes motionless. The surface, after remaining thus tranquil for a little, gets all at once irregularly perturbed, fissures appear in one or several lines, from which flow, in different directions, streams of very fluid silver, which increase the original agitation. The first stage does not yet clearly manifest the presence of gas, and seems to arise from some intestine motion of the particles in their tendency to group, on entering upon the process of crystallization, and thus causing the rupture of the envelop or external crust, and the ejection of some liquid portions.

After remaining some time tranquil, the metal presents a fresh appearance, precisely analogous to volcanic phenomena. As the crystallization continues, the oxygen gas is given out with violence at one or more points, carrying with it melted silver from the interior of the surface, producing a series of cones, generally surmounted by a small crater, vomiting out streams of the metal, which may be seen boiling violently within them.

These cones gradually increase in height by the accumulation of metal thrown up, and that which becomes consolidated on their sloping sides. The thin crust of metal on which they rest, consequently experiences violent impulses, being alternately raised and depressed by such violent agitation, that were it not for the tenacity and elasticity of the metal, there would evidently arise dislocation, fissures, and other analogous accidents. At length several of the craters permanently close, while others continue to allow the gas a passage. The more difficult this is, the more the craters become elevated, and the more their funnels contract by the adhesion or coagulation of a portion of the metal. The projection of globules of silver now becomes more violent; the latter being carried to great distances, even beyond the furnace, and accompanied by a series of explosions, repeated at short intervals. It is generally the last of these little volcanoes that attains the greatest altitude, and exhibits the foregoing phenomena with the greatest energy. It is, moreover, observable, that these cones do not all arise at the same time, some having spent their force, when others commence forming at other points. Some reach the height of an inch, forming bases of two or three inches in diameter. The time occupied by this exhibition is at least from half to three quarters of an hour.

During the formation of these cones, by the evolution of gas, portions of silver are shot forth, which assume, on induration, a form somewhat cylindrical, and often very fantastic, notwithstanding the incompatibility which appears to exist between the fluidity of the silver and these elongated figures. Their appearance is momentary, and without any symptoms of gas, although it is impossible to decide whether they may not arise from its influence; they seem, in fact, to resemble the phenomena of the first volcanic period.

Till very recently, the only operations employed for separating silver from lead in the English smelting-works, were the following:—

1. Cupellation, in which the lead was converted into a vitreous oxyde, which was floated off from the surface of the silver.
2. Reduction of that oxyde, commonly called litharge.
3. Smelting the bottoms of the cupels, to extract the lead which had soaked into them, in a glassy state.

Cupellation and its two complementary operations were, in many respects, objectionable processes; from the injurious effects of the lead vapors upon the health of the workmen; from the very considerable loss of metallic lead, amounting to 7 per cent. at least; and, lastly, from the immense consumption of fuel, as well as from the vast amount of manual labor incurred in such complicated operations. Hence, unless the lead were tolerably rich in silver, it would not bear the expense of cupellation.

The patent process lately introduced by Mr. Pattinson, of Newcastle, is not at all prejudicial to the health of workmen; it does not occasion more than 2 per cent. of loss of lead, and in other respects it is so economical, that it is now profitably applied in Northumberland to alloys too poor in silver to be treated by cupellation. This process is founded upon the following phenomena.

After melting completely an alloy of lead and silver, if we allow it to cool very slowly, continually stirring it meanwhile with a rake, we shall observe at a certain period a continually increasing number of imperfect little crystals, which may be taken out with a drainer, exactly as we may remove the crystals of sea salt deposited during the concentration of brine, or those of sulphate of soda, as its agitated solution cools. On submitting to analysis the metallic crystals thus separated, and also the liquid metal deprived of them, we find the former to be lead almost alone, but the latter to be rich in silver, when compared with the original alloy. The more of the crystalline particles are drained from the metallic bath, the richer does the *mother* liquid become in silver. In practice, the poor lead is raised by this means to the standard of the ordinary lead of the litharge works; and the better lead is made ten times richer. This very valuable alloy is then submitted to cupellation; but as it contains only a tenth part of the quantity of lead subjected to crystallization, the loss in the cupel will be obviously reduced to one tenth of what it was by the former process; that is, seven tenths of a per cent., instead of seven.

These nine tenths of the lead separated by the drainer, are immediately sent into the market, without other loss than the trifling one, of about one half per cent., involved in reviving a little dross skimmed off the surface of the melted metal at the beginning of the operation. Hence the total waste of lead in this method does not exceed two per cent. And as only a small quantity of lead requires to be cupelled, this may be done with the utmost slowness and circumspection; whereby loss of the precious metal, and injury to the health of the work-people, are equally avoided.

The crystallization refinery of Mr. Pattinson is an extremely simple smelting-house. It contains 3 hemispherical cast-iron pans, 41 inches in diameter, and ¾ of an inch thick. The 3 pans are built in one straight line, the broad flange at their edge being supported upon brick-work. Each pan has a discharge pipe, proceeding laterally from one side of its bottom, by which the melted metal may be run out when a plug is withdrawn, and each is heated by a small separate fire.

Three tons of the argentiferous lead constitute one charge of each pan; and as soon as it is melted, the fire is withdrawn; the flue, grate-door, and ash-pit, are immediately closed, and made air-tight with bricks and clay-lute. The agitation is now commenced, with a round bar of iron, terminated with a chisel-point, the workman being instructed merely to keep moving that simple rake constantly in the pan, but more especially towards the edges, where the solidification is apt to begin. He must be careful to take out the crystals, progressively as they appear, with an iron drainer, heated a little higher than the temperature of the metal bath. The liquid metal lifted in the drainer, flows readily back through its perforations, and may be at any rate effectually detached by giving the ladle two or three jogs. The solid portion remains in the form of a spongy, semi-crystalline, semi-pasty mass.

The proportion of crystals separated at each melting, depends upon the original quality of the alloy. If it be poor, it is usually divided in the proportion of two thirds of poor crystals, and one third of rich liquid metal; but this proportion is reversed if the alloy contain a good deal of silver.

Let us exemplify by the common case of a lead containing 10 ounces of silver per ton. Operating upon 3 tons of this alloy, or 60 cwts., containing 30 oz. of silver, there will be obtained in the first operation—

$$\left.\begin{array}{l}(a)\ 40\text{ cwts. at }4\tfrac{1}{2}\text{ ounces of silver per ton; in whole }9\text{ oz.}\\(b)\ 20\text{ cwts. at }21\quad\text{—}\quad\text{—}\quad 21\end{array}\right\}30\text{ oz.}$$

Each of these alloys, (*a*) and (*b*), will be joined to alloys of like quality obtained in the treatment of one or several other portions of three tons of the primitive alloy. Again, three tons of each of these rich alloys are subjected to the crystallization process, and thus in succession. Thus poorer and poorer lead is got on the one hand, and richer and richer alloys on the other. Sometimes the *mother* metal is parted from a great body of poor crystals, by opening the discharge-pipe, and running off the liquid, while the workman keeps stirring, to facilitate the separation of the two.

25 fodders, 15 cwts., 49 lbs. = 540 cwts., 49 lbs. of alloy, holding 5 oz. of silver per fodder, in the whole 130 oz., afforded, after three successive crystallizations,—

	oz.
440 cwts. of poor lead, holding ½ oz. of silver per fodder; in all	10½
15 cwts. 49 — holding the original quantity, nearly -	3½
84 cwts. of lead for the cupel, holding 29 oz. - - - -	116
Total - - - - - - - - -	130

1 cwt. of loss, principally in the reduction of dross.

The expenses of the new method altogether, including 3*s*. per fodder of patent dues, are about one third of the old; being 17*l*. 13*s*. and 54*l*. 16*s*. respectively, upon 84 cwts. of lead, at 29 oz. per fodder.

In the conditions above stated, the treatment of argentiferous lead occasions the following expenses:—

FOR ONE FODDER.	£	s.	d.
By the new process - - - - - - - -	0	13	7
By the old process - - - - - - - - -	2	2	2

Admitting that the treatment of silver holding lead is economically possible only when the profit is equal to one tenth of the gross expenses of the process, we may easily calculate, with the preceding data, that it is sufficient for the lead to have the following contents in silver:—

With the new process, 3 ounces per fodder; or, - - 0·000078
With the old process, $8\frac{4}{70}$ ounces per fodder; or, - - 0·000218

To conclude, the refining by crystallization reduces the cost of the parting of lead and silver, in the proportion of three to one; and allows of extracting silver from a lead which contains only about three oz. per ton. In England, the new method produces at present very advantageous results, especially in reference to the great masses to which it may be applied. In 1828, the quantity of lead annually extracted from the mines in the United Kingdom had been progressively raised to 47,000 tons. Reduced almost to one half of this amount in 1832, by the competition of the mines of la Sierra de Gador, the English production began again to increase in 1833. In 1835, 35,000 tons of lead were obtained, one half of which only having a mean content of eight and a half ounces of silver per ton, was subjected to cupellation, and produced 14,000 oz. of that precious metal. The details of this production are—

Silver extracted from 17,500 tons of lead, holding upon the average eight and a half ounces per ton, - - - - - - - -	140,000 oz.
Silver extracted from silver ores, properly so called, in Cornwall, -	36,000
	176,000

In 1837, the production of lead amounted probably to 40,000 tons; upon which the introduction of the new method would have the effect not only of reducing considerably the cost of parting the 20,000 tons of lead containing 8 oz. of silver per ton, but of permitting the extraction of 4 or 5 oz. of silver, which may be supposed to exist upon an average in the greater portion of the remaining 20,000 tons. Otherwise, this mass of the precious metal would have had no value, or have been unproductive.

There are two oxydes of silver; called argentic oxyde, and suroxyde, by Berzelius. 1. The first is obtained by adding solution of caustic potassa, or lime-water, to a solution of nitrate of silver. The precipitate has a brownish-gray color, which darkens when dried, and contains no combined water. Its specific gravity is 7·143. On exposure to the sun, it gives out a certain quantity of oxygen, and becomes a black powder. This oxyde is an energetic base; being slightly soluble in pure water, reacting like the alkalis upon reddened litmus paper, and displacing, from their combinations with the alkalis, a portion of the acids, with which it forms insoluble compounds. It is insoluble in the caustic leys of potassa or soda. By combination with caustic ammonia, it forms *fulminating silver*. This formidable substance may be prepared by precipitating the nitrate of silver with lime-water, washing the oxyde upon a filter, and spreading it upon gray paper, to make it nearly dry. Upon the oxyde, still moist, water of ammonia is to be poured, and allowed to remain for several hours. The powder which becomes black, is to be freed from the supernatant liquor by decantation, divided into small portions while moist, and set aside to dry upon bits of porous paper. Fulminating silver may be made more expeditiously by dissolving the nitrate in water of pure ammonia, and precipitating by the addition of caustic potassa ley in slight excess. If fulminating silver be pressed with a hard body in its moist state, it detonates with unparalleled violence; nay, when touched even with a feather, in its dry state, it frequently explodes. As many persons have been seriously wounded, and some have been killed, by these explosions, the utmost precautions should be taken, especially by young chemists, in its preparation. This violent phenomenon is caused by the sudden production of water and nitrogen, at the instant when the metallic oxyde is reduced. The quiescent and divellent affinities seem to be so nicely balanced in this curious compound, that the slightest disturbance is sufficient to incite the hydrogen of the ammonia to snatch the oxygen from the silver. The oxyde of silver dissolves in glassy fluxes, and renders them yellow. It consists, according to Berzelius, of 93·11 parts of silver, and 6·89 of oxygen. 2. The suroxyde of silver is obtained by passing a voltaic current through a weak solution of the nitrate; it being deposited, of course, at the positive or oxygenating pole. It is said to crystallize in needles of a metallic lustre, interlacing one another, which are one third of an inch long. When thrown into muriatic acid, it causes the disengagement of chlorine, and the formation of chloride of silver; into water of ammonia, i occasions such a rapid production of nitrogen gas, with a hissing sound, as to convert the whole liquid into froth. If a little of it, mixed with phosphorus, be struck with a hammer, a loud detonation ensues. With heat it decrepitates, and becomes metallic silver.

Sulphuret of silver, which exists native, may be readily prepared by fusing the constituents together; and it forms spontaneously upon the surface of silver exposed to the air of inhabited places, or plunged into eggs, especially rotten ones. The tarnish may be easily removed, by rubbing the metal with a solution of *cameleon mineral*, prepared by calcining peroxyde of manganese with nitre. Sulphuret of silver is a powerful sulphobase; since though it be heated to redness in close vessels, it retains the volatile sulphides, whose combinations with the alkalis are decomposed at that temperature. It consists of 87·04 of silver, and 12·96 of oxygen.

A small quantity of tin, alloyed with silver, destroys its ductility. The best method of separating these two metals, is to laminate the alloy into thin plates, and distil them along with corrosive sublimate. The bichloride of tin comes over in vapors, and condenses in the receiver. Silver and lead, when combined, are separated by heat alone in the process of cupellation, as described in the article Assay, and in the reduction of silver ores. See *suprà*.

An alloy, containing from one twelfth to one tenth of copper, constitutes the silver coin of most nations; being a harder and more durable metal under friction than pure silver. When this alloy is boiled with a solution of cream of tartar and sea-salt, or scrubbed with water of ammonia, the superficial particles of copper are removed, and a surface of fine silver is left.

Chloride of silver is obtained by adding muriatic acid, or any soluble muriate, to a solution of nitrate of silver. A curdy precipitate falls, quite insoluble in water, which being dried and heated to dull redness, fuses into a semi-transparent gray mass, called, from its appearance, *horn-silver*. Chloride of silver dissolves readily in water of ammonia, and crystallizes in proportion as the ammonia evaporates. It is not decomposed by a red heat, even when mixed with calcined charcoal; but when hydrogen or steam is passed over the fused chloride, muriatic acid exhales, and silver remains. When fused along with potassa, (or its carbonate,) the silver is also revived; while oxygen (or also carbonic acid) gas is liberated, and chloride of potassium is formed. Alkaline solutions do not decompose chloride of silver. When this compound is exposed to light, it suffers a partial decomposition, muriatic acid being disengaged. See Assay by the *humid method*.

The best way of reducing the chloride of silver, says Mohr, is to mix it with one third of its weight of colophony, (black rosin,) and to heat the mixture moderately in a crucible till the flame ceases to have a greenish-blue color; then suddenly to increase the fire, so as to melt the metal into an ingot.

The subchloride may be directly formed, by pouring a solution of deuto-chloride of copper or iron upon silver leaf. The metal is speedily changed into black spangles, which, being immediately washed and dried, constitute subchloride of silver. If the contact of the solutions be prolonged, chloride would be formed.

The bromide, cyanide, fluoride, and iodide of silver, have not been applied to any use in the arts. Sulphate of silver may be prepared by boiling sulphuric acid upon the metal. See Refining of Gold and Silver. It dissolves in 88 parts of boiling water, but the greater part of the salt crystallizes in small needles, as the solution cools. It consists of 118 parts of oxyde, combined with 40 parts of dry acid. Solutions of the hyposulphite of potassa, soda, and lime, which are bitter salts, dissolve chloride of silver, a tasteless substance, into liquids possessed of the most palling sweetness, but not at all of any metallic taste.

The iodide of silver is remarkable, like some other metallic compounds, for changing its color alternately with heat and cold. If a sheet of white paper be washed over with a solution of nitrate of silver, and afterwards with a somewhat dilute solution of hydriodate of potash, it will immediately assume the pale yellow tint of the cold silver iodide. On placing the paper before the fire, it will change color from a pale primrose to a gaudy brilliant yellow, like the sun-flower; and on being cooled, it will again resume the primrose hue. These alternations may be repeated indefinitely, like those with the salts of cobalt, provided too great a heat be not applied. The pressure of a finger upon the hot yellow paper makes a white spot, by cooling it quickly.

Fulminate of silver is prepared in the same way as Fulminate *of Mercury*, which see.

On the 10th of February, 1798, the Lords of the Privy Council appointed the Hon. Charles Cavendish, F. R. S., and Charles Hatchett, Esq., F. R. S., to make investigations upon the wear of gold coin by friction. Their admirable experiments were begun in the latter end of 1798, and completed in April, 1801, having been instituted and conducted with every mechanical aid, as devised by these most eminent chemical philosophers, and provided at no small expense, by the government. The following are the important conclusions of their official report:—*

"Gold made standard by a mixture of equal parts of silver and copper, is not so soft as gold alloyed only with silver; neither is it so pale; for it appears to be less removed from the color of fine gold, than either the former or the following metal.

"Gold, when alloyed with silver and copper, when annealed, does not become black, but brown; and this color is more easily removed by the blanching liquor, or solution of alum, than when the whole of the alloy consists of copper. It may also be rolled and stamped with great facility; and, under many circumstances, it appears to suffer less by friction than gold alloyed by silver or copper alone.

"If copper alone forms the alloy, it must be dissolved and separated from the surface of each piece of coin, in the process of annealing and blanching.

"Upon a comparison of the different qualities of the three kinds of standard gold, it appears (strictly speaking) that gold made standard by silver and copper is rather to be preferred for coin."

It will, undoubtedly, seem not a little strange to the uninitiated, that this report, and its important deductions, should have been of late years entirely set at naught, without any scientific reason or research, apparently for the purpose of giving a certain official in our Mint a good job, in sweating out all the silver from our sovereigns, and replacing it, in the new coinage, with copper, taking on an average 3*d*. worth of silver out of each ounce of our excellent gold coin, and charging the country 6½*d*. for its extraction, besides the very considerable expense in providing fine copper to replace the silver. The pretence set up for this extraordinary degradation of the gold, was, that our coin might peradventure be exported, in order to be de-silvered abroad, a danger which could have been most readily averted, by leaving out as much gold in every sovereign as was equivalent to the silver introduced, and thus preserving its intrinsic value in precious metal. When the film of fine gold which covers each of our present pieces has been rubbed off from the prominent parts, these must appear of a very different and deeper color than the flat part or ground of the coin. "The reason, therefore, is sufficiently apparent, says Mr. Hatchett, why gold which is alloyed with silver only, cannot be liable to this blemish;" and with one half of silver alloy, it must be much less liable to it, than with copper alone. Why did the political economists in the recent Committee of the House of Commons on the Mint, blink this question of public economy and expediency?

Gold, as imported from America, Asia, and Africa, contains on an average nearly the right proportion of silver for making the best coin; and were it alloyed to our national standard, of 22 parts of gold, 1 of silver, and 1 of copper, as defined by Messrs. Cavendish and Hatchett, then by simply adding the deficient quantities of one or two of these metals, by the rule of alligation, the very considerable expense would be saved to the nation, and sulphureous nuisance to the Tower Hamlets, now foolishly incurred in de-silvering and cuprifying sovereigns at the Royal Mint.

It was long imagined in Europe, that the average metallic contents of the silver ores of Mexico and Peru, were considerably greater than those of Saxony and Hungary. Much poorer ores, however, are worked among the Cordilleras than in any part of Europe. The mean product of the whole silver ores that are annually reduced in Mexico, amounts only to from 0·18 to 0·25 of a per cent.; that is, from 3 to 4 ounces in 100 lbs.; the true average being, perhaps, not more than 2½. It is by their greater profusion of ores, not their superior richness, that the mines of South America surpass those of Europe.

GOLD and SILVER produced in Forty Years, from 1790 to 1830.

	Gold.	Silver.
Mexico, - - - - - -	£6,436,453	£139,818,032
Chile, - - - - - - -	2,768,488	1,822,924
Buenos Ayres, - - - - - -	·4,024,895	27,182,673
Russia, - - - - - - -	3,703,743	1,502,981

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* It is inserted in the Philosophical Transactions for 1802.

RETURNS of the DOLLARS coined at the different Mints in MEXICO.

	1829.	1830.	1831.	1834.
Mexico - -	1,280,000	1,090,000	1,386,000	952,000
Guanajuato - -	2,406,000	2,560,000	2,603,000	2,703,000
Zacatecas - -	4,505,000	5,190,000	4,965,000	5,527,000
Guadalaxara - -	596,000	592,000	590,000	715,000
Durango - -	659,000	453,000	358,000	1,215,000
San Luis - -	1,613,000	1,320,000	1,497,000	928,000
Ilalpan - -	728,000	90,000	323,000	—
Total - -	11,787,000	11,295,000	11,722,000	12,040,000

The returns for 1832 and 1833 are wanting.

PERU.—RETURNS of GOLD and SILVER coined at the Mints of Lima and Casco.

	Gold.	Silver.	Total, in Dollars.
1830	180,000	2,015,000	2,195,000
1831	92,000	2,384,000	2,476,000
1832	94,000	3,210,000	3,284,000
1833	150,000	2,990,000	3,140,000
1834	110,000	3,150,000	3,260,000

RETURNS of SILVER in BARS produced at the different Smelting-works in PERU.

	Lima.	Truxillo.	Pasco.	Ayacucho.	Puno.	Arequipa.	Total, in Dollars.
1830	270,000	190,000	780,000	120,000	250,000	150,000	1,760,000
1831	270,000	60,000	1,110,000	70,000	310,000	110,000	1,930,000
1832	290,000	100,000	1,800,000	70,000	345,000	25,000	2,640,000
1833	222,000	70,000	2,130,000	50,000	25,000	65,000	2,562,000

RETURNS of SILVER in DOLLARS exported from the Provinces of CHILI.

	Coquimbo.	Huasco.	Copiano.
1831	785,000	115,000	670,000
1832	316,000	—	36,000
1833	490,000	100,000	585,000
	1,591,000	215,000	1,291,000

SANTIAGO—Mint Coinage.

Gold.	Silver.	Total.
1832, 174,000; 1833, 392,500	1832, 42,000; 1833, 92,000	700,500

The production of SILVER in the kingdom of SAXONY amounted to—
59,231 marcs and 8 loths, in the year 1825
55,023 — — — 1826
60,034 — — — 1827
61,361 — — — 1828
65,176 — and 10 loths — 1830
65,886 — — — 1832
The mine of Himmelfürst alone produces annually 10,000 marcs.

The quantity of SILVER produced in the PRUSSIAN States was—
22,135 marcs in 1825 20,612 marcs in 1829
20,071 — 1826 20,887 — 1830
18,631 — 1827 mmmmmm 19,031 — 1831
21,731 — 1828 22,083 — 1832

The whole annual production of Europe, and Asiatic Russia, has been rated by Humboldt at 292,000 marcs, by other authorities at 310,000 marcs; while at the beginning of the present century, that of the Spanish colonies in America was 3,349,160 marcs, or nearly twelve times as much. The sum total is 3,704,160 marcs, of 3609 grains troy each; which is nearly 1,900,000 lbs. avoirdupois; that is, little less than 9000 tons.

The English Mint silver contains 222 pennyweights of fine silver, and 18 of copper, in the troy pound of 240 pennyweights: or 92·5 in 100 parts. 1 pound troy = 5760 grains, contains 65·8 shillings, each weighing 87·55 grains. The French silver coin contains one tenth of copper, and a franc weighs 5 grammes = 77·222 grains troy. The Prussian dollar (*thaler*) is the standard coin; 10½ *thaler* weigh 1 marc; hence, 1 *thaler* weighs 343·7 grains troy, and contains 257·9 grains of fine silver; being 75 per cent. of silver, and 25 of alloy. The Austrian coin contains $\frac{13}{288}$ of alloy, according to Wasserberg; which is only 4½ per cent.

SILVER LEAF is made in precisely the same way as *gold leaf*, to which article I must therefore refer the reader.

SILVERING is the art of covering the surfaces of bodies with a thin film of silver. When silver leaf is to be applied, the methods prescribed for gold leaf are suitable. Among the metals, copper or brass are those on which the silverer most commonly operates. Iron is seldom silvered; but the processes for both metals are essentially the same.

The principal steps of this operation are the following:—

1. The *smoothing down* the sharp edges, and polishing the surface of the copper; called *émorfiler* by the French artists.
2. The *annealing*; or making the piece to be silvered red-hot, and then plunging it in very dilute nitric acid, till it be bright and clean.
3. *Pumicing*; or clearing up the surface with pumice-stone and water.
4. The *warming*, to such a degree merely as, when it touches water, it may make a slight hissing sound; in which state it is dipped in the very weak aquafortis, whereby it acquires minute insensible asperities, sufficient to retain the silver leaves that are to be applied.
5. The *hatching*. When these small asperities are inadequate for giving due solidity to the silvering, the plane surfaces must be hatched all over with a graving tool; but the chased surfaces need not be touched.
6. The *blueing* consists in heating the piece till its copper or brass color changes to blue. In heating, they are placed in hot tools made of iron, called *mandrins* in France.
7. The *charging*, the workman's term for silvering. This operation consists in placing the silver leaves on the heated piece, and fixing them to its surface by burnishers of steel, of various forms. The workman begins by applying the leaves double. Should any part darken in the heating, it must be cleared up by the scratch-brush.

The silverer always works two pieces at once; so that he may heat the one while burnishing the other. After applying two silver leaves, he must heat up the piece to the same degree as at first, and he then fixes on with the burnisher four additional leaves of silver; and he goes on *charging* in the same way, 4 or 6 leaves at a time, till he has applied, one over another, 30, 40, 50, or 60 leaves, according to the desired solidity of the silvering. He then burnishes down with great pressure and address, till he has given the surface a uniform silvery aspect.

Silvering by the precipitated chloride of silver.—The white curd obtained by adding a solution of common salt to one of nitrate of silver, is to be well washed and dried. One part of this powder is to be mixed with 3 parts of good pearlash, one of washed whiting, and one and a half of sea salt. After clearing the surface of the brass, it is to be rubbed with a bit of soft leather, or cork moistened with water, and dipped in the above powder. After the silvering, it should be thoroughly washed with water, dried, and immediately varnished. Some use a mixture of 1 part of the silver precipitate with 10 of cream of tartar, and this mixture also answers very well.

Others give a coating of silver by applying with friction, in the moistened state, a mixture of 1 part of silver-powder precipitated by copper, 2 parts of cream of tartar, and as much common salt. The piece must be immediately washed in tepid water very faintly alkalized, then in slightly warm pure water, and finally wiped dry before the fire. See PLATED MANUFACTURE.

The inferior kinds of plated buttons get their silver coating in the following way:—

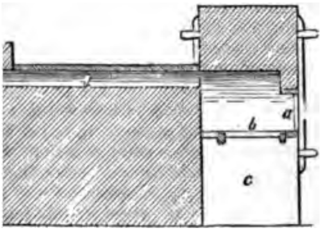
2 ounces of chloride of silver are mixed up with 1 ounce of corrosive sublimate, 3 pounds of common salt, and 3 pounds of sulphate of zinc, with water, into a paste. The buttons being cleaned, are smeared over with that mixture, and exposed to a moderate degree of heat, which is eventually raised nearly to redness, so as to expel the mercury from the amalgam, formed by the reaction of the horn silver and the corrosive sublimate. The copper button thus acquires a silvery surface, which is brightened by clearing and burnishing.

Leather is silvered by applying a coat of parchment size, or spirit varnish, to the surface, and then the silver leaf, with pressure.

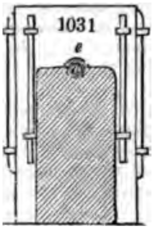
SIMILOR is a golden-colored variety of brass.

:ING OF WEBS. The old furnace for singeing cotton goods is repre-
longitudinal section, *fig.* 1030, and in a transverse one in *fig.* 1031. *a* is the fire-door; *b* the grate; *c*, the ash-pit; *d*, a flue 6 inches broad, and 2½ high, over which a hollow semi-cylindrical mass of cast iron *e*, is laid, one inch thick at the sides, and 2½ thick at the top curvature. The flame passes
fire-flue *d*, into a side opening *f*, in the chimney. The goods are swept swiftly
ignited piece of iron, with considerable friction, by means of a wooden roller,
ing frame for raising them at any moment out of contact.

1030



1031

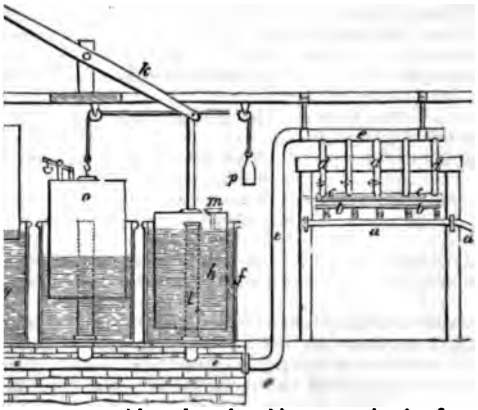


e shops, semi-cylinders of copper, three quarters of an inch thick, have been
d for those of iron, in singeing goods prior to bleaching them. The former
months, and do 1500 pieces with one ton of coal; while the latter, which are
nd a half thick, wear out in a week, and do no more than from 500 to 600 pieces
same weight of fuel.

early part of the year 1818, Mr. Samuel Hall enrolled the specification of a
removing the downy fibres of the cotton thread from the interstices of bobbi-
or muslins, which he effected by singeing the lace with the flame of a gas-
The second patent granted to Mr. Hall, in April, 1823, is for an improvement
ove process; viz., causing a strong current of air to draw the flame of the gas
he interstices of the lace, as it passes over the burner, by means of an aperture
placed immediately above the row of gas-jets, which tube communicates with an
or exhauster.

32 shows the construction of the apparatus complete, and manner in which it
a, *a*, is a gas-pipe, supplied by an ordinary gasometer; from this pipe, several small ones extend upwards to the long burner *b*, *b*. This burner is a horizontal tube, perforated with many small holes on the upper side, through which, as jets, the gas passes; and when it is ignited, the bobbinet lace, or other material intended to be singed, is extended and drawn rapidly over the flame, by means of rollers, which are not shown in the figure.

1032



The simple burn-
: gas, even with a draught chimney, as in the former specification, is found
at all times efficacious; the patentee, therefore, now introduces a hollow
with a slit or opening, immediately over the row of burners; and this tube,
of the pipes *d*, *d*, *d*, communicates with the pipe *e*, *e*, *e*, which leads to the
g apparatus.

:hausting apparatus consists of two tanks, *f* and *g*, nearly filled with water,
nverted boxes or vessels, *h* and *i*, which are suspended by rods to the vibrating
each of the boxes is furnished with a valve opening upwards; *l*, *l*, are pipes
from the horizontal part of the pipe *e*, up into the boxes or vessels *h* and *i*,
es have valves at their tops, also opening upward. When the vessel *h* de-
e water in the tank forces out the air contained within the vessel at the valve
hen that vessel rises again, the valve *m* being closed, the air is drawn from
, through the pipe *l*. The same takes place in the vessel *i*, from which the
descent is expelled through the valve *n*, and, in its ascent, draws the air

through the pipe *l*, from the pipe *e*. By these means, a partial exhaustion is effected in the pipe *e*, *e*, and the tube *c*, *c*; to supply which, the air rushes with considerable force through the long opening of the tube *c*, *c*, and carries with it the flame of the gas-burners. The bobbinet lace, or other goods, being now drawn over the flame between the burner *b*, *b*, and the exhausted tube *c*, *c*, by means of rollers, as above said, the flame of the gas is forced through the interstices of the fabric, and all the fine filaments and loose fibres of the thread are burnt off, without damaging the substance of the goods.

To adjust the draught from the gas-burners, there are stopcocks introduced into several of the pipes *d*; and to regulate the action of the exhausting apparatus, an air vessel *o*, is suspended by a cord or chain passing over pulleys, and balanced by a weight *p*. There is also a scraper introduced into the tube *c*, which is made, by any convenient contrivance, to revolve and slide backwards and forwards, for the purpose of removing any light matter that may arise from the goods singed, and which would otherwise obstruct the air passage. Two of these draught tubes *c*, may be adapted and united to the exhausting apparatus, when a double row of burners is employed, and the inclination of the flame may be directed upwards, downwards, or sideways, according to the position of the slit in the draft tube, by which means any description of goods may, if required, be singed on both sides at one operation.

The greater part of the bobbinet lace made in England, is sent to Mr. Hall's works, at Basford, near Nottingham, to be singed; and at a reduction of price truly wonderful. He receives now only one farthing for what he originally was paid one shilling.

SKIN (*Peau*, Fr.; *Haut*, Germ.), the external membrane of animal bodies, consists of three layers: 1. the epidermis, scarf-skin, (*Oberhaut*, Germ.); 2. the vascular organ, or papillary body, which performs the secretions; and 3. the true skin, (*Lederhaut*, Germ.), of which leather is made. The skin proper, or dermoid substance, is a tissue of innumerable very delicate fibres, crossing each other in every possible direction, with small orifices between them, which are larger on its internal than on its external surface. The conical channels thus produced are not straight, but oblique, and filled with cellular membrane; they receive vessels and nerves which pass out through the skin (*cutis vera*), and are distributed upon the secretory organ. The fibrous texture of the skin is composed of the same animal matter as the serous membranes, the cartilages, and the cellular tissue; the whole possessing the property of dissolving in boiling water, and being, thereby, converted into glue. See GLUE, LEATHER, and TAN.

SLAG (*Laitier*, Fr.; *Schlacke*, Germ.), is the vitreous mass which covers the fused metals in the smelting-hearths. In the iron-works it is commonly called *cinder*. Slags consist, in general, of bi-silicates of lime and magnesia, along with the oxydes of iron and other metals; being analogous in composition, and having the same crystalline form as the mineral, *pyroxene*. See COPPER and IRON.

SLATES (*Ardoises*, Fr.; *Schiefern*, Germ.) The substances belonging to this class may be distributed into the following species:—

1. Mica-slate, occasionally used for covering houses.
2. Clay-slate, the proper roofing-slate.
3. Whet-slate.
4. Polishing-slate.
5. Drawing-slate, or black chalk.
6. Adhesive slate.
7. Bituminous shale.
8. Slate-clay.

1. *Mica slate.*—This is a mountain rock of vast continuity and extent, of a schistose texture, composed of the minerals mica and quartz, the mica being generally predominant.

2. *Clay-slate.*—This substance is closely connected with mica; so that uninterrupted transitions may be found between these two rocks in many mountain chains. It is a simple schistose mass, of a bluish-gray or grayish-black color, of various shades, and a shining, somewhat pearly internal lustre on the faces, but of a dead color in the cross fracture.

Clay-slate is extensively distributed in Great Britain. It skirts the Highlands of Scotland, from Lochlomond by Callender, Comrie, and Dunkeld; resting on, and gradually passing into mica-slate throughout the whole of that territory. Roofing-slate occurs, on the western side of England, in the counties of Cornwall and Devon; in various parts of North Wales and Anglesea; in the north-east parts of Yorkshire, near Ingleton, and in Swaledale; as also in the counties of Cumberland and Westmoreland. It is likewise met with in the county of Wicklow and other mountainous districts of Ireland.

All the best beds of roofing-slate improve in quality as they lie deeper under the surface; near to which, indeed, they have little value.

A good roofing-slate should split readily into thin even laminæ; it should not be absorbent of water either on its face or endwise, a property evinced by its not increasing perceptibly in weight after immersion in water; and it should be sound, compact, and not apt to disintegrate in the air. The slate raised at Eisdale, on the west coast of Argyllshire, is very durable.

Cleaving and dressing of the slates.—The splitter begins by dividing the block, cut lengthwise, to a proper size, which he rests on end, and steadies between his knees. He uses a mallet and a chisel, which he introduces into the stone in a direction parallel to the *folia*. By this means he reduces it into several manageable pieces, and he gives to each the requisite length, by cutting cross grooves on the flat face, and then striking the slab with the chisel. It is afterwards split into thinner sections, by finer chisels dexterously applied to the edges. The slate is then dressed to the proper shape, by being laid on a block of wood, and having its projecting parts at the ends and sides cut off with a species of hatchet or chopping-knife. It deserves to be noticed, that blocks of slate may lose their property of divisibility into thin laminæ. This happens from long exposure to the air, after they have been quarried. The workmen say, then, that they have lost their waters. For this reason, the number of splitters ought to be always proportioned to the number of block-hewers. Frost renders the blocks more fissile; but a supervening thaw renders them quite refractory. A new frost restores the faculty of splitting, though not to the same degree; and the workmen therefore avail themselves of it without delay. A succession of frosts and thaws renders the quarried blocks quite intractable.

3. *Whet-slate*, or *Turkey hone*, is a slaty rock, containing a great proportion of quartz, in which the component particles, the same as in clay-slate and mica-slate, but in different proportions, are so very small as to be indiscernible.

4. *Polishing slate.* Color, cream-yellow, in alternate stripes; massive; composition impalpable; principal fracture, slaty, thin, and straight; cross fracture, fine earthy; feels fine, but meager; adheres little, if at all, to the tongue; is very soft, passing into friable; specific gravity in the dry state, 0·6; when imbued with moisture, 1·9. It is supposed to have been formed from the ashes of burnt coal. It is found at Planitz, near Zwickau, and at Kutschlin near Bilin in Bohemia.

5. *Drawing-slate*, or *black chalk;* has a grayish-black color; is very soft, sectile, easily broken, and adheres slightly to the tongue; spec. grav. 2·11. The streak is glistening. It occurs in beds in primitive and transition clay-slate; also in secondary formations, as in the coal-measures of most countries. It is used in crayon drawing. Its trace upon paper is regular and black. The best kinds are found in Spain, Italy, and France. Some good black chalk occurs also in Caernarvonshire and in the island of Islay.

6. *Adhesive slate*, has a light greenish-gray color, is easily broken or exfoliated, has a shining streak, adheres strongly to the tongue, and absorbs water rapidly, with the emission of air-bubbles and a crackling sound.

7. *Bituminous shale*, is a species of soft, sectile slate-clay, much impregnated with bitumen, which occurs in the coal-measures.

8. *Slate-clay*, has a gray or grayish-yellow color; is massive, with a dull glimmering lustre from spangles of mica interspersed. Its slaty fracture approaches at times to earthy; fragments, tabular; soft, sectile, and very frangible; specific gravity, 2·6. It adheres to the tongue, and crumbles down when immersed for some time in water. It is found as an alternating bed in the coal-measures. (See the sections of the strata under Pitcoal.) When breathed upon, it emits a strong argillaceous odor. When free from lime and iron, it forms an excellent material for making refractory fire-bricks, being an infusible compound of alumina and silica; one of the best examples of which is the schist known by the name of Stourbridge clay.

SMALL WARES, is the name given in this country to textile articles of the tape kind, narrow bindings of cotton, linen, silk, or woollen fabric; plaited sash cord, braid, &c. Tapes are woven upon a loom like that for weaving ribands, which is now generally driven by mechanical power. Messrs. Worthington and Mulliner obtained a patent, in June, 1825, for improvements in such a loom, which have answered the purposes of their large factory in Manchester very well; and in May, 1831, Mr. Whitehead, of the same town, patented certain improvements in the manufacture of small wares. The objects of the latter patent are, the regular taking up of the tape or cloth, as it is woven, a greater facility of varying the vibration of the lay, together with the saving of room required for a range of looms to stand in.* See Braiding Machine.

SMALT, see Azure and Cobalt.

Imported for home consumption in 1834, 162,232 lbs.; in 1835, 96,649; in 1836, 79,531; duty, 4*d.* per lb.

SMELTING, is the operation by which the ores of iron, copper, lead, &c., are reduced to the metallic state. See Metallurgy, Ores, and the respective metals.

SOAP (*Savon*, Fr.; *Seife*, Germ.), is a chemical compound, of saponified fats or oils with potash or soda, prepared for the purposes of washing linen, &c. Fatty matters, when subjected to the action of alkaline leys, undergo a remarkable change, being converted into three different acids, called stearic, margaric, and oleic; and it is these acids, in fact, which combine with the bases, in definite proportions, to form compounds analogous to the neutro-saline. Some chemical writers describe under the title soap, every compound which may result from the union of fats with the various earths and metallic oxydes—a latitude of nomenclature which common language cannot recognise, and which would perplex the manufacturer.

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* Newton's London Journal, vol. xiii. p. 198; and vol. i. combined series, p. 212.

Soaps are distinguished into two great classes, according to their consistence; the hard and the soft; the former being produced by the action of soda upon fats, the latter by that of potash. The nature of the fats contributes also somewhat to the consistence of soaps; thus tallow, which contains much stearine and margarine, forms with potash a more consistent soap than liquid oils will do, which consist chiefly of oleine. The drying oils, such as those of linseed and poppy, produce the softest soaps.

1. *Of the manufacture of hard soap.*—The fat of this soap, in the northern countries of Europe, is usually tallow, and in the southern, coarse olive oil. Different species of grease are saponified by soda, with different degrees of facility; among oils, the olive, sweet almond, rapeseed, and castor oil; and among solid fats, tallow, bone grease, and butter, are most easily saponified. According to the practice of the United Kingdom, six or seven days are required to complete the formation of a pan of hard soap, and a day or two more for settling the impurities, if it contains rosin. From 12 to 13 cwts. of tallow are estimated to produce one ton of good soap. Some years ago, in many manufactories the tallow used to be saponified with potash leys, and the resulting soft soap was converted, in the course of the process, into hard soap, by the introduction of muriate of soda, or weak kelp leys, in sufficient quantity to furnish the proper quantity of soda by the reaction of the potash upon the neutral salts. But the high price of potash, and the diminished price as well as improved quality of the crude sodas, have led to their general adoption in soap-works. The soda-ash used by the soap-boiler, contains in general about 36 per cent. of real soda, in the state of dry carbonate, mixed with muriate of soda, and more or less undecomposed sulphate. I have met lately with soda-ash, made from sulphate of soda, in which the materials had been so ill worked, and so imperfectly decomposed, as to contain 16 per cent. of sulphate, a circumstance equally disgraceful, as it was ruinous to the soda manufacturer. The barillas from Spain and Teneriffe contain from 18 to 24 per cent. of real soda. The alkali in both states is employed in England; barilla being supposed by many to yield a finer white or curd soap, on account of its freedom from sulphur.

The crude soda of either kind being ground, is to be stratified with lime in cylindrical cast-iron vats, from 6 to 7 feet wide, and from 4 to 5 feet deep; the lowest layer consisting, of course, of unslaked or shell quicklime. The vats have a false bottom, perforated with holes, and a lateral tubulure under it, closed commonly with a wooden plug, similar to the *épine* of the French soap pans, by which the leys trickle off clear and caustic, after infiltration through the beds of lime. The quantity of lime must be proportional to the carbonic acid in the soda.

Upon 1 ton of tallow put into the soap pan, about 200 gallons of soda ley, of specific gravity 1·040, being poured, heat is applied, and after a very gentle ebullition of about 4 hours, the fat will be found to be completely saponified, by the test of the spatula, trowel, or pallet knife; for the fluid ley will be seen to separate at once upon the steel blade, from the soapy paste. Such leys, if composed of pure caustic soda, would contain 4 per cent. of alkali; but from the presence of neutro-saline matter, they seldom contain so much as 2 per cent.; in fact, a gallon may be estimated to contain not more than 2 ounces; so that 200 gallons contain 25 pounds of real soda. The fire being withdrawn from the soap pan, the mass is allowed to cool during one hour, or a little more, after which the spent leys, which are not at all alkaline, are run off by a spigot below, or pumped off above, by a pump set into the pan. A second similar charge of ley is now introduced into the pan, and a similar boiling process is renewed. Three such boils may be given in the course of one day's work, by an active soap-maker. Next day the same routine is resumed with somewhat stronger leys, and so progressively, till, towards the sixth day, the ley may have the density of 1·160, and will be found to contain 6 per cent. of real soda.* Were the ley a solution of pure caustic soda, it would contain at this density no less than 14¾ per cent. of alkali. The neutro-saline matter present in the spent ley is essential to the proper granulation and separation of the saponaceous compound; for otherwise the watery menstruum would dilute and even liquefy the soap. Supposing 12½ cwts. of tallow to yield upon an average 20 cwts. of hard soap, then 20 cwts. of tallow will produce 32 cwts.; and as its average contents in soda are 6 per cent., these 32 cwts. should require 1·52 cwts. of real soda for their production. If barilla at 20 per cent. be the alkali employed, then 7·6 cwts. of barilla must be consumed in the said process.

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* According to my own experiments upon the soda ley used in the London soap-works.

If the alkali be soda-ash of 40 per cent., half the weight will of course suffice. I have reason to believe that there is great waste of alkali incurred in many soap-works, as 6 cwts. of soda-ash, of at least 30 per cent., are often expended in making 1 ton of soap, being 50 per cent. more than really enters into the composition of the soap.

The barillas always contain a small proportion of potash, to which their peculiar value, in making a less brittle or more plastic hard soap than the factitious sodas, may with great probability be ascribed. Chemistry affords many analogies, especially in mineral waters, where salts, apparently incompatible, co-exist in dilute solutions. We may thus conceive how a small quantity of stearate or oleate of potash may resist the decomposing action of the soda salts. The same modification of the consistence of hard soap may, however, be always more conveniently produced by a proper admixture of oleine with stearine.

Soda which contains sulphurets is preferred for making the mottled or marbled soap, whereas the desulphureted soda makes the best white curd soap. Mottling is usually given in the London soap-works, by introducing into the nearly finished soap in the pan a certain quantity of the strong ley of crude soda, through the rose spout of a watering-can. The dense sulphureted liquor, in descending through the pasty mass, causes the marbled appearance. In France a small quantity of solution of sulphate of iron is added during the boiling of the soap, or rather with the first service of the leys. The alkali seizes the acid of the sulphate, and sets the protoxyde of iron free, to mingle with the paste, to absorb more or less oxygen, and to produce thereby a variety of tints. A portion of oxyde combines also with the stearine to form a metallic soap. When the oxyde passes into the red state, it gives the tint called *manteau Isabelle*. As soon as the *mottler* has broken the paste, and made it pervious in all directions, he ceases to push his rake from right to left, but only plunges it perpendicularly, till he reaches the ley; then he raises it suddenly in a vertical line, making it act like the stroke of a piston in a pump, whereby he lifts some of the ley, and spreads it over the surface of the paste. In its subsequent descent through the numerous fissures and channels, on its way to the bottom of the pan, the colored ley impregnates the soapy particles in various forms and degrees, whence a varied marbling results.

Three pounds of olive oil afford five pounds of marbled Marseilles soap of good quality, and only four pounds four ounces of white soap; showing that more water is retained by the former than the latter. Oils of grains, as linseed and rapeseed, do not afford so solid a soda soap as oil of olives; but tallow affords a still harder soap with soda. Some of the best Windsor soap made in London contains one part of olive oil (gallipoli) for every nine parts of tallow. Much of the English hard soap is made with kitchen and bone fat, of a very coarse quality; the washing of the numerous successive leys, however, purifies the foul fats, and deprives them of their offensive smell in a great degree. It is common now at Marseilles to mix ten per cent. of the oil of grains with olive oil; for which purpose a large proportion of the oils extracted from seeds in the mills of the *Department du Nord* is sent to Marseilles; but five per cent. of poppy-seed oil, mixed with tallow, renders the soap made with the mixture stringy and unfit for washing; because the two species of fat refuse to amalgamate.

The affinity between the stearine of tallow and the alkali, is so great that a soap may be speedily made from them in the cold. If we melt tallow at the lowest possible temperature, and let it cool to the fixing point, then add to it half its weight of caustic ley, at 36° B., agitating meanwhile incessantly with a pallet knife, we shall perceive, at the end of some hours of contact, the mixture suddenly acquire a very solid consistence, and at the same moment assume a marked elevation of temperature, proving the phenomenon to be due to chemical attraction. In some trials of this kind, the thermometer has risen from 54° to 140° F.

According to recent experiments made in Marseilles, 100 pounds of olive oil take, for their conversion into soap, 54 pounds of crude soda, of 36 per cent. alkaline strength. One part of lime is employed for rendering three parts of the soda caustic. The richer the oil is in stearine, the more dilute should be the ley used in the saponification; and *vice versâ* when it abounds in oleine. For oil of the former kind, the first leys added have a density of from 8° to 9° B.; but for the latter kind, the density is from 10° to 11°. When four parts of olive oil are mixed with one part of poppy, rape, or linseed oil, as is now the general practice at Marseilles. then for such a mixture the first leys have usually a specific gravity of from 20° to 25°, the second from 10° to 15°, and the third from 4° to 5°, constituting a great difference from the practice in Great Britain, where the weaker leys are generally employed at the commencement. The chief reason for this practice is, however, to be found in the more complete causticity of the weak than of the strong leys, according to the slovenly way in which most of our soap-boilers prepare them. Indeed, one very extensive manufacturer of soap in London assured me that the leys should not be caustic; an extraordinary assertion, upon which no comment need be made. In common cases, I would recommend the first combination of the ingredients to be made with somewhat weak, but perfectly caustic ley, and when the saponification is fairly established, to introduce the stronger ley.

In a Marseilles soap-house, there are four ley-vats in each set: No. 1 is the *fresh vat*, into which the fresh alkali and lime are introduced; No. 2 is called the *avançaire*, being one step in advance; No. 3 is the small *avançaire*, being two steps in advance, and therefore containing *weaker* liquor; No. 4 is called the *water* vat, because it receives the water directly.

Into No. 3 the moderately exhausted or somewhat spent leys are thrown. From No. 3 the ley is run or pumped into No. 2, to be strengthened; and in like manner from No. 3 into No. 1. Upon the lime paste in No. 4, which has been taken from No. 3, water is poured; the ley thus obtained is poured upon the paste of No. 3, which has been taken from No. 2. No. 3 is twice lixiviated; and No. 2, once. The receiver under No. 1 has four compartments; into No. 1 of which the first and strongest ley is run; into No. 2 the second ley; into No. 3 the third ley; and into No. 4 the fourth ley, which is so weak as to be used for lixiviation, instead of water; (*pour d'avances*).

The lime of vat No. 4, when exhausted, is emptied out of the window near to which it stands; in which case the water is poured upon the contents of No. 3; and upon No. 2 the somewhat spent leys.

No. 1 is now the *avançaire* of No. 4; because this has become, in its turn, the *fresh* vat, into which the fresh soda and quicklime are put. The ley discharged from No. 3 comes, in this case, upon No. 2; and after being run through it, is thrown upon No. 1.

144 pounds of oil yield at Marseilles, upon an average, not more than from 240 to [illegible] pounds of soap; or 100 pounds yield about 168; so that in making 100 pounds of soap, at this rate nearly 60 pounds of oil are consumed.

OF YELLOW OR ROSIN SOAP.

Rosin, although very soluble in alkaline menstrua, is not however susceptible, like fats, of being transformed into an acid, and will not of course saponify, or form a proper soap by itself. The more caustic the alkali, the less consistence has the resinous compound which is made with it. Hence fat of some kind, in considerable proportion, must be used along with the rosin, the *minimum* being equal parts; and then the soap is far from being good. As alkaline matter cannot be neutralized by rosin, it preserves its peculiar acrimony in a soap poor in fat, and is ready to act too powerfully upon woollen and all other animal fibres to which it is applied. It is said that rancid tallow serves to mask the strong odor of rosin in soap, more than any oil or other species of fat. From what we have just said, it is obviously needless to make the rosin used for yellow soaps pass through all the stages of the saponifying process; nor would this indeed be proper, as a portion of the rosin would be carried away, and wasted with the spent leys. The best mode of proceeding, therefore, is first of all to make the hard soap in the usual manner, and at the last service or charge of ley, namely, when this ceases to be absorbed, and preserves in the boiling-pan its entire causticity, to add the proportion of rosin intended for the soap. In order to facilitate the solution of the rosin in the soap, it should be reduced to coarse powder, and well incorporated by stirring with the rake. The proportion of rosin is usually from one third to one fourth the weight of the tallow. The boil must be kept up for some time with an excess of caustic ley; and when the paste is found, on cooling a sample of it, to acquire a solid consistence, and when diffused in a little water, not to leave a resinous varnish on the skin, we may consider the soap to be finished. We next proceed to draw off the superfluous leys, and to purify the paste. For this purpose, a quantity of leys at 80° B. being poured in, the mass is heated, worked well with a rake, then allowed to settle, and drained of its leys. A second service of leys, at 4° B., is now introduced, and finally one at 2°; after each of which, there is the usual agitation and period of repose. The pan being now skimmed, and the scum removed for another operation, the soap is laded off by hand-pails into its frame-moulds. A little palm oil is usually employed in the manufacture of yellow soap, in order to correct the flavor of the rosin, and brighten the color. This soap, when well made, ought to be of a fine wax-yellow hue, be transparent upon the edges of the bars, dissolve readily in water, and afford, even with hard pump-water, an excellent lather.

The frame-moulds for hard soap are composed of strong wooden bars, made into the form of a parallelogram, which are piled over each other, and bound together by screwed iron rods, that pass down through them. A square well is thus formed, which in large soap factories is sometimes 10 feet deep, and capable of containing a couple of tons of soap.

Mr. Sheridan some time since obtained a patent for combining silicate of soda with hard soap, by triturating them together in the hot and pasty state with a crutch in an iron pan. In this way from 10 to 30 per cent. of the silicate may be introduced. Such soap possesses very powerful detergent qualities, but it is apt to feel hard and be somewhat gritty in use. The silicated soda is prepared by boiling ground flints in a strong caustic ley, till the specific gravity of the compound rises to nearly double the density of water. It then contains about 35 grains of silica, and 46 of soda-hydrate, in 100 grains.*

Hard soap, after remaining two days in the frames, is at first divided horizontally into parallel tablets, 3 or 4 inches thick, by a brass wire; and these tablets are again cut vertically into oblong nearly square bars, called wedges in Scotland.

The soap-pans used in the United Kingdom are made of cast iron, and in three separate pieces joined together by iron-rust cement. The following is their general form:— The two upper frusta of cones are called curbs; the third, or undermost, is the pan, to which alone the heat is applied, and which, if it gets cracked in the course of boiling, may easily be lifted up within the conical pieces, by attaching chains or cords for raising it, without disturbing the masonry, in which the curbs are firmly set. The surface of the hemispherical pan at the bottom, is in general about one tenth part of the surface of the conical sides.

The white ordinary tallow soap of the London manufacturers, called curd soap, consists, by my experiments, of—fat, 52; soda, 6; water, 42; = 100. Nine tenths of the fat, at least, is tallow.

I have examined several other soaps, and have found their composition somewhat different.

The foreign Castile soap of the apothecary has a specific gravity of 1·0705, and consists of—

Soda	9
Oily fat	76·5
Water and coloring-matter	14·5
	100·0

English imitation of Castile soap, spec. grav. 0·9669, consists of—

Soda	10·5
Pasty consistenced fat	75·2
Water, with a little coloring-matter	14·3
	100·0

A perfumer's white soap was found to consist of—

Soda	9
Fatty matter	75
Water	16
	100

Glasgow white soap—

Soda	6·4
Tallow	60·0
Water	33·6
	100·0

Glasgow brown rosin soap—

Soda	6·5
Fat and rosin	70·0
Water	23·5
	100·0

A London cocoa-nut oil soap was found to consist of—

Soda	4·5
Cocoa-nut lard	22·0
Water	73·5
	100·0

This remarkable soap was sufficiently solid; but it dissolved in hot water with extreme facility. It is called marine soap, because it washes linen with sea water.

A poppy-nut-oil hard soap consisted of—

Soda	7
Oil	76
Water	17
	100†

The soap known in France by the name of *soap in tables*, consists, according to M. Thenard's analysis, of—

Soda	4·6
Fatty matter	50·2
Water	45·2
	100·0

M. D'Arcet states the analysis of Marseilles soap at—

Soda	6
Oil	60
Water	34
	100

SOFT SOAP.

The principal difference between soaps with base of soda, and soaps with base of potash, depends upon their mode of combination with water. The former absorb a large quantity of it, and become solid; they are chemical hydrates. The others experience a much feebler cohesive attraction; but they retain much more water in a state of mere mixture.

Three parts of fat afford, in general, fully five parts of soda soap, well dried in the open air; but three parts of fat or oil will afford from six to seven parts of potash soap of moderate consistence. This feebler cohesive force renders it apt to deliquesce, especially if there be a small excess of the alkali. It is, therefore, impossible to separate it from the leys; and the washing or *relargage*, practised on the hard-soap process, is inadmissible in the soft. Perhaps, however, this concentration or abstraction of water might be effected by using dense leys of muriate of potash. Those of muriate or sulphate of soda change the potash into a soda soap, by double decomposition. From its superior solubility, more alkaline reaction, and lower price, potash soap is preferred for many purposes, and especially for scouring woollen yarns and stuffs.

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* By my own experiments upon the liquid silicate made at Mr. Gibbs' excellent soap factory.

† My own experiments. See Fats, Oils, and Stearine.

Soft soaps are usually made in this country with whale, seal, olive, and linseed oils, and a certain quantity of tallow; on the continent, with the oils of hempseed, sesame, rapeseed, linseed, poppy-seed, and colza; or with mixtures of several of these oils. When tallow is added, as in Great Britain, the object is to produce white and somewhat solid grains of stearic soap in the transparent mass, called figging, because the soap then resembles the granular texture of a fig.

The potash leys should be made perfectly caustic, and of at least two different strengths; the weakest being of specific gravity 1·05; and the strongest, 1·20, or even 1·25. Being made from the potashes of commerce, which contain seldom more than 60 per cent., and often less, of real alkali, the leys correspond in specific gravity to double their alkaline strength; that is to say, a solution of pure potash, of the same density, would be fully twice as strong. The following is the process followed by respectable manufacturers of soft soap (*savon vert*, being naturally or artificially green) upon the continent.

A portion of the oil being poured into the pan, and heated to nearly the boiling point of water, a certain quantity of the weaker ley is introduced; the fire being kept up so as to bring the mixture to a boiling state. Then some more oil and ley are added alternately, till the whole quantity of oil destined for the pan is introduced. The ebullition is kept up in the gentlest manner possible, and some stronger ley is occasionally added, till the workman judges the saponification to be perfect. The boiling becomes progressively less tumultuous, the frothy mass subsides, the paste grows transparent, and it gradually thickens. The operation is considered to be finished when the paste ceases to affect the tongue with an acrid pungency, when all milkiness and opacity disappear, and when a little of the soap placed to cool upon a glass plate, assumes the proper consistency.

A peculiar phenomenon may be remarked in the cooling, which affords a good criterion of the quality of the soap. When there is formed around the little patch, an opaque zone, a fraction of an inch broad, this is supposed to indicate complete saponification, and is called the *strength;* when it is absent, the soap is said to want its *strength*. When this zone soon vanishes after being distinctly seen, the soap is said to have *false* strength. When it occurs in the best form, the soap is perfect, and may be secured in that state by removing the fire, and then adding some good soap of a previous round, to cool it down, and prevent further change by evaporation.

200 pounds of oil require for their saponification—72 pounds of American potash of moderate quality, in leys at 15° B.; and the product is 460 pounds of well-boiled soap.

If hempseed oil have not been employed, the soap will have a yellow color, instead of the green, so much in request on the continent. This tint is then given by the addition of a little indigo. This dye-stuff is reduced to fine powder, and boiled for some hours in a considerable quantity of water, till the stick with which the water is stirred presents, on withdrawing it, a gilded pellicle over its whole surface. The indigo paste diffused through the liquid, is now ready to be incorporated with the soap in the pan, before it stiffens by cooling.

M. Thenard states the composition of soft soap at—potash 9·5, + oil 44·0, + water 46·5, = 100.

Good soft soap of London manufacture, yielded to me—potash 8·5, + oil and tallow 45, + water 46·5.

Belgian soft or green soap afforded me—potash 7, + oil 36, + water 57, = 100.

Scotch soft soap, being analyzed, gave me—potash 8, + oil and tallow 47, + water 45.

Another well-made soap—potash 9, + oil and fat 34, + water 57.

A rapeseed-oil soft soap, from Scotland, consisted of—potash 10, + oil 51·66, + water 38·33.

An olive-oil (gallipoli) soft soap, from ditto, contained—potash with a good deal of carbonic acid 10, oil 48, water 42, = 100.

A semi-hard soap, from Verviers, for fulling woollen cloth, called *savon économique*, consisted of, potash 11·5, + fat (solid) 62, + water 26·5, = 100.

The following is a common process, in Scotland, by which good soft soap is made:—

273 gallons of whale or cod oil, and 4 cwts. of tallow, are put into the soap-pan, with 250 gallons of ley from American potash, of such alkaline strength that 1 gallon contains 6600 grains of real potash. Heat being applied to the bottom pan, the mixture froths up very much as it approaches the boiling temperature, but is prevented from boiling over by being beat down on the surface, within the iron curb or crib which surmounts the caldron. Should it soon subside into a doughy-looking paste, we may infer that the ley has been too strong. Its proper appearance is that of a thin glue. We should now introduce about 42 gallons of a stronger ley, equivalent to 8700 gr. of potash per gallon; and after a short interval, an additional 42 gallons; and thus suc-

cessively till nearly 600 such gallons have been added in the whole. After suitable boiling to saponify the fats, the proper quality of soap will be obtained, amounting in quantity to 100 firkins of 64 pounds each, from the above quantity of materials.

It is generally supposed, and I believe it to be true, from my own numerous experiments upon the subject, that it is a more difficult and delicate operation to make a fine soft soap of glassy transparency, interspersed with the figged granulations of stearate of potash, than to make hard soap of any kind.

Soft soap is made in Belgium as follows:—For a boil of 18 or 20 tons, of 100 kilogrammes each, there is employed for the leys—1500 pounds of American potashes, and 500 to 600 pounds of quicklime.

The ley is prepared cold in cisterns of hewn stone, of which there are usually five in a range. The first contains the materials nearly exhausted of their alkali; and the last the potash in its entire state. The ley run off from the first, is transferred into the second; that of the second into the third; and so on to the fifth.

In conducting the *empatage* of the soap, they put into the pan, on the eve of the boiling-day, 6 *aimes* (1 ohm, = 30 gallons imperial) of oil of colza, in summer, but a mixture of that oil with linseed oil in winter, along with 2 aimes of potash ley at 13° B., and leave the mixture without heat during eight hours. After applying the fire, they continue to boil gently till the materials cease to swell up with the heat; after which, ley of 16° or 17° must be introduced successively, in quantities of ¼ of an aime after another, till from 2 to 4 aimes be used. The boil is finished by pouring some ley of 20° B., so that the whole quantity may amount to 9½ aimes.

It is considered that the operation will be successful, if from the time of kindling the fire till the finish of the boil, only five hours elapse. In order to prevent the soap from boiling over, a wheel is kept revolving in the pan. The operative considers the soap to be finished, when it can no longer be drawn out into threads between the finger and thumb. He determines if it contains an excess of alkali, by taking a sample out during the boil, which he puts into a tin dish; where if it gets covered with a skin, he pours fresh oil into the pan, and continues the boil till the soap be perfect. No wonder the Belgian soap is bad, amid such groping in the dark, without one ray of science!

SOFT TOILET SOAPS.

The soft fancy toilet soaps are divisible into two classes: 1. good *potash soap*, colored and scented in various ways, forms the basis of the Naples and other ordinary soft soaps of the perfumer; 2. *pearl soap*, (*savon nacré*,) which differs from the other both in physical aspect and in mode of preparation.

Ordinary soft Toilet Soap.—Its manufacture being conducted on the principles already laid down, presents no difficulty to a man of ordinary skill and experience; the only point to be strictly attended to, is the degree of evaporation, so as to obtain soap always of uniform consistence. The fat generally preferred is good hog's lard; of which thirty pounds are to be mixed with forty-five pounds of a caustic ley marking 17° on Baumé's scale; the temperature is to be gradually raised to ebullition, but the boil must not be kept up too long or too briskly, till after the *empatage* or saponification is completed, and the whole of the ley intimately combined with the fatty particles; after this, the evaporation of the water may be pushed pretty quickly, by a steady boil, till copious vapors cease to rise. This criterion is observed when the paste has become too stiff to be stirred freely. The soap should have a dazzling snowy whiteness, provided the lard has been well refined, by being previously triturated in a mortar, melted by a steam heat, and then strained. The lard soap so prepared, is semi-solid, and preserves always the same appearance. If the paste is not sufficiently boiled, however, it will show the circumstance very soon; for in a few days the soap will become gluey and stringy, like a tenacious mass of birdlime. This defect may not only be easily avoided, but easily remedied, by subjecting the paste to an adequate evaporation. Such soaps are in great request for shaving, and are most convenient in use, especially for travellers. Hence their sale has become very considerable.

Pearl soft Soap.—It is only a few years since the process for making this elegant soap became known in France. It differs little from the preceding, and owes its beautiful aspect merely to minute manipulations, about to be described. Weigh out 20 pounds of purified hog's lard on the one hand, and 10 pounds of potash ley at 36° B. on the other. Put the lard into a porcelain capsule, gently heated upon a sand-bath, stirring it constantly with a wooden spatula; and when it is half melted, and has a milky appearance, pour into it only one half of the ley, still stirring, and keeping up the same temperature, with as little variation as possible. While the saponification advances gradually, we shall perceive, after an hour, some fat floating on the surface, like a film of oil, and at the same time the soapy granulations falling to the bottom. We must then add the second portion of the ley; whereon the granulations immediately disappear and the paste is formed. After conducting this operation during four hours, the paste becomes so stiff and compact, that it cannot be stirred; and must then be lightly beaten. At this time the capsule must be transferred from the sand-bath into a basin of warm water, and allowed to cool very slowly.

The soap, though completely made, has yet no pearly appearance. This physical property is developed only by pounding it strongly in a marble mortar; whereby all its particles, which seemed previously separated, combine to form a homogeneous paste. The perfume given to it, is always essence of bitter almonds; on which account the soap is called *almond cream, crème d'amandes.*

HARD SOAPS FOR THE TOILET.

The soaps prepared for the perfumer, are distinguished into different species, according to the fat which forms their basis. Thus there is soap of tallow, of hog's lard, of oil of olives, of almonds, and palm oil.

It is from the combination of these different sorts, mingled in various proportions, and perfumed agreeably to the taste of the consumer, that we owe the vast number of toilet soaps sold under so many fantastic names. One sort is rarely scented by itself, as a mixture of several is generally preferred; in which respect every perfumer has his peculiar secret. Some toilet soaps, however, require the employment of one kind more than of another.

Formerly the Windsor soap was made in France, wholly with mutton suet; and it was accordingly of inferior value. Now, by mixing some olive oil or lard with the suet, a very good Windsor soap is produced. I have already stated, that the fat of the London Windsor is, nine parts of good ox tallow, and one of olive oil. A soap made entirely with oil and soda, does not afford so good a lather as when it contains a considerable proportion of tallow.

The soaps made with palm oil are much used; when well made, they are of excellent quality, and ought to enter largely into all the colored sorts. They naturally possess the odor of violets.

The soaps made with oil of almonds are very beautiful, and preserve the agreeable smell of their perfume; but being expensive, are introduced sparingly into the mixtures by most manufacturers.

Some perfumers are in the habit of making what may be called extempore soaps, employing leys at 36° Baumé in their formation. This method, however, ought never to be adopted by any person who prefers quality to beauty of appearance. Such soap is, indeed, admirably white, glistening, contains no more water than is necessary to its constitution, and may therefore be sold the day after it is made. But it has counter-balancing disadvantages. It becomes soon very hard, is difficultly soluble in water, and, if not made with tallow, does not lather well. Hog's lard is very commonly used for making that soap. Twenty kilogrammes of the fat are taken, to ten kilogrammes of soda ley, at 36° B. (specific gravity 1·324); as soon as the former is nearly fluid, five kilogrammes of the ley are introduced, and the mixture is continually agitated during an hour with a wooden spatula. The temperature should never be raised above 150° Fahr. at the commencement of the operation; at the end of one hour, five other kilogrammes of ley are to be added, with careful regulation of the heat. The paste thus formed by the union of the fat and alkali, ought to be perfectly homogeneous, and should increase in consistence every hour, till it becomes firm enough to be poured into the frame; during which transfer, the essential oils destined to scent it, should be introduced. Next day the soap is hard enough; nor does it differ in appearance from ordinary soap, only it requires prompt manipulation to be cut into bars and cakes; for when neglected a day or two, it may become too brittle for that purpose, and too hard to take the impression of the stamps in relief. Such an article gets the name of *little-pan soap,* on account of the small quantity in which it is usually manufactured. Hard soap, made in the common way, is, on the contrary, called *large-pan soap.* This extemporaneous compound is now seldom or never made by respectable manufacturers. In making Windsor soap, the admixture of olive oil is advantageous; because, being richer in oleine than suet, it saponifies less readily than it, and thus favors the formation of a more perfect neutral combination. When the soap cuts, or parts from the ley, when the paste becomes clotty, or, in the language of the operative, when the grain makes its appearance, the fire should be immediately withdrawn, that the impurities may be allowed to subside. This part of the operation lasts twelve hours at least; after which, the soap, still hot, becomes altogether fluid and perfectly neutral.

For every 1000 pounds of the paste, there must be introduced nine pounds of essences, mingled in the following proportions:—six pounds of essence of carui; one and a half ditto lavender, (finest); one and a half ditto rosemary.

The mixture must be well stirred, in order to get completely saturated with the perfumes; and this may be readily done without at all touching or stirring up the subjacent leys; in the course of two hours, the soap may be transferred into the ordinary frames. In twenty-four hours, the mass is usually solidified enough for cutting into bars and cakes, ready to be stamped for sale.

The above method of scenting Windsor soap is practised only in the largest establishments; in the smaller, the soap is pailed out of the soap-pans, into a pan provided with a steam case or jacket, and there mixed with the essential oils, by means of appropriate heat and agitation.

The most fashionable toilet soaps are, the rose, the *bouquet*, the cinnamon, the orange-flower, the musk, and the bitter almond or peach blossom.

Soap à la rose.—This is made of the following ingredients: 30 pounds of olive-oil soap; 20 of good tallow soap.

Toilet soaps must be reduced to thin shavings, by means of a plane, with its under face turned up, so that the bars may be slid along it. These shavings must be put into an untinned copper pan, which is surrounded by a water-bath, or steam. If the soap be old and hard, 5 pounds of water must be added to them; but it is preferable to take fresh-made soaps, which may melt without addition, as soap some time kept does not readily form a homogeneous paste. The fusion is commonly completed in an hour, or thereby, the heat being applied at 212° F., to accelerate the progress, and prevent the dissolution of the constituent water of the soap. For this purpose the interior pan may be covered. Whenever the mass is sufficiently liquefied, 1½ ounces of finely ground vermilion are to be introduced, and thoroughly mixed, after which the heat may be taken off the pan; when the following perfumes may be added with due trituration:—3 ounces of essence of rose; 1 ditto cloves; 1 ditto cinnamon; 2½ ditto bergamot; = 7½.

The scented soap being put into the frames, speedily consolidates. Some recommend to pass the finished fused soap through a tammy cloth, in order to free it from all clots and impurities; a very proper precaution in the act of transferring it to the frame. If the preceding instructions be observed, we obtain a soap perfect in every point of view; possessing a delicious fragrance, equally rich and agreeable, a beautiful roseate hue, and the softest detergent qualities, which keeping cannot impair. Such a soap has, in fact, been known to retain every property in perfection during four or five years. When the essential oils are particularly volatile, they should not be added to the soap till its temperature has fallen to about 140° Fahr.; but in this case a more careful trituration is required. The economy is, however, ill bestowed; for the cakes made of such cooler soap are never so homogeneous and glossy.

Soap au bouquet.—30 pounds of good tallow soap; 4 ounces of essence of bergamot; oil of cloves, sassafras, and thyme, 1 ounce each; neroli, ½ ounce. The color is given with 7 ounces of brown ochre.

Cinnamon Soap.—30 pounds of good tallow soap; 20 ditto of palm-oil soap. Perfumes:—7 ounces of essence of cinnamon; 1¼ ditto sassafras; 1¼ ditto bergamot. Color:—1 pound of yellow ochre.

Orange-flower Soap.—30 pounds of good tallow soap; 20 ditto palm-oil soap. Perfumes:—7½ ounces essence of Portugal; 7½ ditto amber. Color:—9½ ounces, consisting of 8¼ of a yellow-green pigment, and 1¼ of red lead.

Musk Soap.—30 pounds of good tallow soap; 20 ditto palm-oil soap. Perfumes:—Powder of cloves, of pale roses, gilliflower, each 4½ ounces; essence of bergamot, and essence of musk, each 3½ ounces. Color:—4 ounces of brown ochre, or Spanish brown.

Bitter Almond Soap—Is made by compounding, with 50 pounds of the best white soap, 10 ounces of the essence of bitter almonds.

LIGHT SOAPS.

The apparatus employed for making these soaps is a copper pan, heated by a water-bath; in the bottom of the pan there is a step, to receive the lower end of a vertical shaft, to which arms or paddles are attached, for producing constant agitation, by causing them to revolve among the liquefied mass. Into a pan so mounted, 50 pounds of good oil soap of any kind are put (for a tallow soap does not become frothy enough), and melted by proper heat, with the addition of 3 or 4 pounds of water. By the rapid rotation of the machine, an abundant thick lather is produced, beginning first at the bottom, and creeping gradually upwards to the top of the pan, when the operation should be stopped; the soap having by this time doubled its volume. It must now be pailed off into the frame, allowed to cool, and then cut into cakes. Such soap is exceedingly pleasant at the wash-stand, feeling very soft upon the skin, affording a copious thick lather, and dissolving with the greatest ease.

TRANSPARENT SOAPS.

These soaps were for a long time manufactured only in England, where the process was kept a profound secret. They are now made every where.

Equal parts of tallow soap, made perfectly dry, and spirit of wine, are to be put into a copper still, which is plunged in a water-bath, and furnished with its capital and refrigeratory. The heat applied to effect the solution should be as slight as possible, to avoid evaporating too much of the alcohol. The solution being effected, must be suffered to settle; and after a few hours' repose, the clear supernatant liquid is drawn off into tin frames, of the form desired for the cakes of soap. These bars do not acquire their proper degree of transparency till after a few weeks' exposure to dry air. They are now planed, and subjected to the proper mechanical treatment for making cakes of any form. The soap is colored with strong alcoholic solution of archil for the rose tint, and of turmeric for the deep yellow. Transparent soaps, however pleasing to the eye, are always of indifferent quality; they are never so detergent as ordinary soaps, and they eventually acquire a disagreeable smell.

Soap charged with duty in	1834.	1835.	1836.
	lbs.	*lbs.*	*lbs.*
Hard - - - - - -	144,344,043	148,806,207	146,539,210
Soft - - - - - - -	10,401,281	12,103,109	13,358,894
Amount of duty at 1½*d.* per lb. on hard soap	£902,150	£930,039	£915,861
do. at 1*d.* soft soap	43,339	50,429	55,662

SOAPSTONE; see STEATITE.

SODA, *Caustic soda* (*Hydrate de soude*, Fr.; *Aetznatron*, Germ.), is an alkaline substance, used in chemical researches, in bleaching, and in the manufacture of soap. It is prepared by boiling a solution of crystallized carbonate of soda in 4 or 5 parts of water, with half its weight of recently slaked and sifted lime. At the end of half an hour, the vessel of iron, porcelain, or preferably silver, may be removed from the fire, and covered carefully, till the calcareous matter has settled into a solid magma at the bottom. The clear supernatant ley may be then decanted into bottles for use in the liquid state, or evaporated, out of contact of air, till it assumes an oily appearance, then poured upon an iron or marble slab, broken into pieces, and put up in vials secured with greased stoppers or corks.

Caustic soda is a white brittle mass, of a fibrous texture, a specific gravity of 1·536, melting at a heat under redness, having a most corrosive taste and action upon animal matters, dissolving readily in both water and alcohol, attracting carbonic acid when exposed to the atmosphere, but hardly any water, and falling thereby into an efflorescent carbonate; it forms soaps with tallow, oils, wax, rosin; dissolves wool, hair, silk, horn, alumina, silica, sulphur, and some metallic sulphurets. It consists of 77·66 soda, and 22·34 water. A solution of caustic soda affords no precipitate with solution of chloride of platinum, or tartaric acid, as a solution of caustic potash never fails to do.

The following TABLE of the quantity of CAUSTIC SODA contained in LEYS of different densities, has been given by Richter:—

Spec. grav.	Soda per cent.	Spec. grav.	Soda per cent.	Spec. grav.	Soda per cent.	Spec. grav.	Soda per cent
1·00	0·00	1·12	11·10	1·22	20·66	1·32	29·96
1·02	2·07	1·14	12·81	1·24	22·58	1·34	31·67
1·04	4·02	1·16	14·73	1·26	24·47	1·35	32·40
1·06	5·89	1·18	16·73	1·28	26·33	1·36	33·08
1·08	7·69	1·20	18·71	1·30	28·16	1·38	34·41
1·10	9·43						

Soda free from water can be obtained only by the combustion of *sodium*, which see.

SODA, CARBONATE OF (*Kohlensaures natron*, Germ.), is the soda of commerce in various states, either crystallized, in lumps, or in a crude powder called soda-ash. It exists in small quantities in certain mineral waters; as, for example, in those of Seltzer, Seydschutz, Carlsbad, and the volcanic springs of Iceland, especially the Geyser; it frequently occurs as an efflorescence in slender needles upon damp walls, being produced by the action of the lime upon the sea salt present in the mortar. The mineral soda is the sesquicarbonate, to be afterwards described.

Of manufactured soda, the variety most anciently known is barilla, the incinerated ash of the *Salsola soda*. This plant is cultivated with great care by the Spaniards, especially in the vicinity of Alicant. The seed is sown in light low soils, which are embanked towards the sea shore, and furnished with sluices, for admitting an occasional overflow of salt water. When the plants are ripe, the crop is cut down and dried; the seeds are rubbed out and preserved; the rest of the plant is burned in rude furnaces, at a temperature just sufficient to cause the ashes to enter into a state of semi-fusion, so as to concrete on cooling into cellular masses moderately compact. The most valuable variety of this article is called *sweet barilla.* It has a grayish-blue color, and gets covered with a saline efflorescence when exposed for some time to the air. It is hard and difficult to break; when applied to the tongue, it excites a pungent alkaline taste.

I have analyzed many varieties of barilla. Their average quantity of free or alkalimetrical soda is about 17 per cent.; though several contain only 14 parts in the hundred, and a few upwards of 20. This soda is chiefly a carbonate, with a little sulphuret and sulphite; and is mixed with sulphate and muriate of soda, carbonate of lime, vegetable carbon, &c.

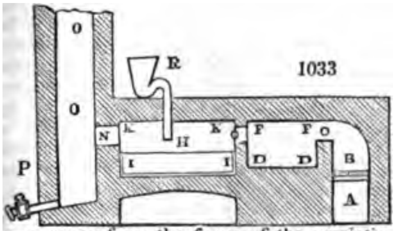
Another mode of manufacturing crude soda, is by burning sea-weed into kelp. Formerly very large revenues were derived by the proprietors of the shores of the Scottish islands and Highlands, from the incineration of sea-weed by their tenants, who usually paid their rents in kelp; but since the tax has been taken off salt, and the manufacture of a crude soda from it has been generally established, the price of kelp has fallen extremely low.

The crystals of soda-carbonate, as well as the soda-ash of British commerce, are now made altogether by the decomposition of sea salt.

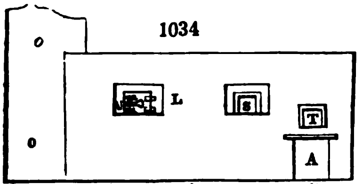
SODA MANUFACTURE.

The manufacture divides itself into three branches:—1. The conversion of sea salt, or chloride of sodium, into sulphate of soda. 2. The decomposition of this sulphate into crude soda, called *black balls* by the workmen. 3. The purification of these balls, either into a dry white soda-ash or into crystals.

1. *The preparation of the sulphate of soda.*—*Figs.* 1033, 1034, 1035, represent the furnace for converting the muriate of soda into the sulphate. The furnace must be built interiorly of the most refractory fire-bricks, such as are used for glasshouses, but of the ordinary brick size; except the bridges C, G, N, which should be formed of one mass, such as what is called a Welsh lump. A is the ash-pit; B, the grate; C, the first bridge, between the fire and the first calcining hearth D, D; F, F, is its roof; G, the second bridge, between the calcining hearth and the decomposing hearth I, I, I; the roof of which is K, K. This hearth I, I, is lined with a lead square pan, 5 or 6 inches deep, sloped at the back opening, in *fig.* 1035, marked M'; which deficient part of the upright side is filled up with two bricks placed one over the other, as shown at *m*, *m*, *fig.* 1034, and luted with clay, to confine the semi-liquid mass in the pan, I, I. Some manufacturers make this pan 8 inches deep, and line its bottom and sides with bricks or silicious sandstone, to protect the lead from the corrosive action of the acid. There are others who consider this precaution troublesome, as the points of the pan which become leaky are thereby concealed. In the roof of the decomposing hearth, one or two syphon funnels R, of lead, are inserted when the charge of acid (sulphuric) is to be poured down upon the salt in I, I, to save the risk of any annoyance from the fumes of the muriatic acid. O, O, is a chimney filled with round flint nodules, which are kept continually moist by the trickling of a streamlet of water upon the topmost layer. The muriatic gas, meeting this descending film of water upon so extensive a surface, becomes absorbed, and runs out below in a liquid form. When the acid is required in a somewhat concentrated state, this chimney should be made both high and capacious. Such a plan, moreover, is very valuable for abating the nuisance caused by the disengagement of the muriatic acid gas; which is otherwise apt to sterilize the surrounding vegetation.



1033

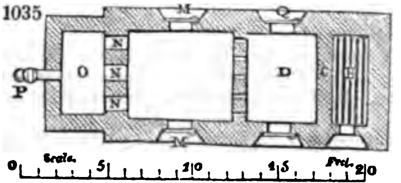


1034

A fire being kindled in the grate B, *figs.* 1033 and 1034, 3 cwts. of salt in powder are to be thrown by a shovel into the pan I, through the door M, *fig.* 1035, or *m*, *m*, *fig.* 1034. Two hundred weights and a half of oil of vitriol, of specific gravity 1·844, having been diluted with from 25 to 30 per cent. of water, and well mixed, or 3 cwts. at 56° Baumé, are to be slowly poured in by the funnel, and diffused among the muriate of soda, by an occasional stir with an iron rake cased with sheet lead. Fumes of muriatic acid will now plentifully escape, and, passing up the condensing-shaft O, will flow down in the form of liquid spirit of salt, and escape by the stoneware stopcock P, into the pipe of a sunk cistern. The fire having been steadily kept up at a moderate degree, the chemical reaction will be tolerably complete in the course of two hours; but as this is relative to the nature of the fuel, and the draught of the furnace, no very precise rule in point of time can be laid down; but it is sufficient for this stage of the process, when the fumes cease to be very dense and copious, as may be ascertained by opening the door M, and looking in, or by the appearance at the top of the shaft O. Over the door M′, in the opposite side of the decomposing hearth, *fig.* 1035, there must be an arch or hood terminating in a small chimney, 15 or 20 feet high, for the ascent of the muriatic vapors, when the charge is drawn or run out of the hearth, and allowed to fall into a square shallow iron tray, placed on the ground at the back of the furnace. For this discharge, the two bricks which serve as stoppers to that orifice, must be unluted and removed.

As soon as that charge is taken out, (the fire being meanwhile checked by opening the door T, *fig.* 1034, and shutting partially the ash-pit opening at A,) a fresh charge must be introduced as above described. The nearly decomposed saline matter, during the second charging of the hearth I, will have grown cool and concrete. It must be shovelled into the calcining hearth D, D, *fig.* 1033, by the back door Q, *fig.* 1035, where it will receive a higher degree of heat; and, by the expulsion of the remaining part of the muriatic acid, it will become a perfect sulphate of soda. It should be finally brought into a state of semi-fusion. When a sample of it, taken out on the end of the rake or trowel-shaped scraper, emits no fumes, the conversion is accomplished.

1035

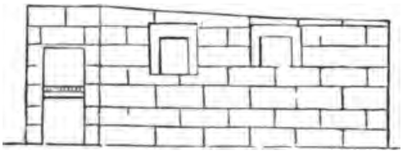


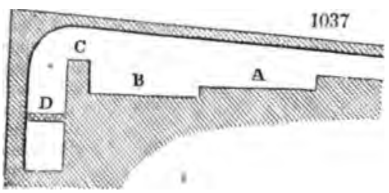
From 3 cwts. of common salt, or muriate of soda, rather more than 3½ cwts. of perfect sulphate should be obtained, quite free from metallic impurity.

The next step is the conversion of the sulphate into a crude soda.

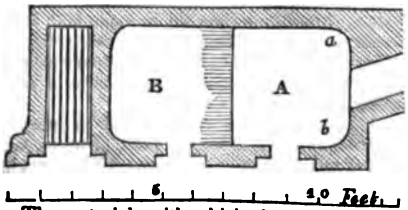
One of the most improved soda furnaces is that employed in a few factories, represented in *figs.* 1036, 1037, and 1038. In the section *fig.* 1037, there are two hearths in one furnace, the one elevated above the level of the other by the thickness of a brick, or about 3 inches. A is the preparatory shelf, where the mixture to be decomposed is first laid in order to be thoroughly heated, so that when transferred to the lower or decomposing hearth B, it may not essentially chill it, and throw back the operation. C is the fire-bridge, and D is the grate. In the horizontal section, or ground plan, *fig.* 1038, we see an opening in the front corresponding to each hearth. This is a door, as shown in the side view or elevation of the furnace, *fig.* 1036; and each door is shut by an iron square frame filled with a fire-tile or bricks, and suspended by a chain over a pulley fixed in any convenient place. See PITCOAL, COKING OF, p. 1047. The workman, on pushing up the door lightly, makes it rise, because there is a counterweight at the other end of each chain, which balances the weight of the frame and bricks. In the ground plan, only one smoke-flue is shown; and this construction is preferred by many manufacturers; but others choose to have two flues, one from each shoulder, as at *a*, *b*; which two flues afterwards unite in one vertical chimney, from 25 to 40 feet high; because the draught of a soda-furnace must be very sharp. Having sufficiently explained the construction of this improved furnace, I shall now proceed to describe the mode of making soda with it.

1036





1038



The materials with which the sulphate is decomposed into a rough carbonate of soda, are chalk or ground limestone, and ground coal or charcoal. The proportions in which these three substances are mixed, influence in a remarkable degree the success of the decomposing process. I have known a false proportion introduced, and persevered in, at a factory, with the most prejudicial effect to the product; the soda-ash produced being in a small quantity relatively to the sulphate employed, and being much charged with sulphur. After very numerous trials which I have made on the great scale, and many inquiries at the most successful soda-works, both in this country and abroad, I am warranted to offer the following proportions as the most profitable :—

Sulphate of soda, 100 parts; carbonate of lime (chalk or limestone), from 110 to 120 parts; if pure, 110; if a little impure or damp, 120; pitcoal, 50 parts.

These materials must be separately ground by an edge-stone mill, and sifted into a tolerably fine powder. They must be then very carefully mixed. Attention to these particulars is of no little importance to the success of the soda process.

One hundred parts or pounds of sulphate of soda are equivalent to 75 parts of carbonate, and when skilfully decomposed, will generally yield fully 70 pounds. A charge for the decomposing furnace with the preparatory shelf should not exceed 200 lbs., or perhaps 180; therefore if 75 pounds of ground sulphate of soda, with 80 pounds of chalk or limestone (ground), and 37 pounds of ground coal, be well mixed, they will constitute one charge. This charge must be shovelled in upon the hearth A, or shelf of preparation, (*fig.* 1037); and whenever it has become hot (the furnace having been previously brought to bright ignition), it is to be transferred to the decomposing hearth or laboratory B, by an iron tool, shaped exactly like an oar, called the spreader. This tool has the flattened part from 2 to 3 feet long, and the round part, for laying hold of and working by, from 6 to 7 feet long. Two other tools are used; one, a rake, bent down like a garden hoe at the end; and another, a small shovel, consisting of a long iron rod terminated with a piece of iron plate, about 6 inches long, 4 broad, sharpened and tipped with steel, for cleaning the bottom of the hearth from adhering cakes or crusts. Whenever the charge is shoved by the sliding motion of the oar down upon the working hearth, a fresh charge should be thrown into the preparation shelf, and evenly spread over its surface.

The hot and partially carbonized charge being also evenly spread upon the hearth B, is to be left untouched for about ten minutes, during which time it becomes ignited, and begins to fuse upon the surface. A view may be taken of it through a peep-hole in the door, which should be shut immediately, in order to prevent the reduction of the temperature. When the mass is seen to be in a state of incipient fusion, the workman takes the oar and turns it over breadth by breadth in regular layers, till he has reversed the position of the whole mass, placing on the surface the particles which were formerly in contact with the hearth. Having done this, he immediately shuts the door, and lets the whole get another decomposing heat. After five or six minutes, jets of flame begin to issue from various parts of the pasty-consistenced mass. Now is the time to incorporate the materials together, turning and spreading by the oar, gathering them together by the rake, and then distributing them on the reverse part of the hearth; that is, the oar should transfer to the part next the fire-bridge the portion of the mass lying next the shelf, and *vice versa.* The dexterous management of this transposition characterizes a good soda-furnacer. A little practice and instruction will render this operation easy to a robust clever workman. After this transposition, incorporation, and spreading, the door may be shut again for a few minutes, to raise the heat for the finishing off. Lastly, the rake must be dexterously employed to mix, shift, spread, and incorporate. The jets, called *candles*, are very numerous, and bright at first; and whenever they begin to fade, the mass must be raked out into cast-iron moulds, placed under the door of the laboratory to receive the ignited paste.

One batch being thus worked off, the other, which has lain undisturbed on the shelf, is to be shoved down from A to B, and spread equally upon it, in order to be treated as above described. A third batch is then to be placed on the shelf.

The article thus obtained should contain at least 22 per cent. of real soda, equivalent to 37 per cent. of dry carbonate, or to 100 of crystals. A skilful workman can turn out a batch in from three quarters of an hour to an hour, producing a perfect carbonate, which yields on solution an almost colorless liquid, nearly destitute of sulphur, and containing hardly any decomposed sulphate.

In some soda-works, where the decomposing furnace is very large, and is charged with a ton of materials at a time, it takes two men to work it, and from five to six hours to complete a batch. Having superintended the operation of the above-described small furnace, and examined its products, I feel warranted to recommend its adoption.

The following materials and products show the average state of this soda process :—

Materials.—100 parts of sulphate of soda, ground, equivalent to 75 of carbonate; 110 of chalk or ground limestone; 55 of ground coal; in the whole, 265.

Products.—168 parts of crude soda, at 33 per cent. = 55·5 of dry carbonate.

Or, { 130 — crystals of carbonate of soda = 48 of dry carbonate; and
{ 100 — insoluble matter.

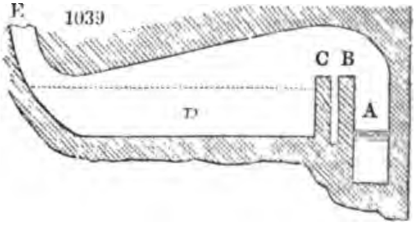
But these products necessarily vary with the skill of the workman.

In another manufactory the following proportions are used:—Six stones, of 14 lbs. each, of dry ground sulphate of soda, are mixed with 3 of chalk and 3 of coal. This mixture, weighing 1½ cwt., forms a batch, which is spread upon the preparation shelf of the furnace (*figs.* 1037 and 1038), as above described, and gradually heated to incipient ignition. It is then swept forwards to the lower area B, by the iron oar, and spread evenly by the rake. Whenever it begins to soften under the rising heat of the laboratory (the side doors being meanwhile shut), the mass must be laboriously turned over and incorporated; the small shovel, or paddle, being employed to transfer, by the interchange of small portions at a time, in rapid but orderly succession, the whole materials from the colder to the hotter, and from the hotter to the colder parts of the hearth. The process of working one batch takes about an hour, during the first half of which period it remains upon the preparation shelf. The average weight of the finished ball is 1 cwt., and its contents in alkalimetrical soda are 33 pounds.

Where the acidulous sulphate of iron from pyrites may be had at a cheap rate, it has been long ago employed, as at Hurlett in Scotland, instead of sulphuric acid, for decomposing the chloride of sodium. Mr. Turner's process of preparing soda, by decomposing sea salt with litharge and quicklime, has been long abandoned, the resulting patent yellow, or sub-chloride of lead, having a very limited sale.

2. *The extraction of pure soda from the crude article.*—The black balls must be broken into fragments, and thrown into large square iron cisterns, furnished with false bottoms of wooden spars; when the cisterns are nearly full of these lumps, water is pumped in upon them, till they are all covered. After a few days, the lixiviation is effected, and the ley is drawn off either by a syphon or by a plug-hole near the bottom of the cistern, and run into evaporating vessels. These may be of two kinds. The surface-evaporating furnace, shown in *fig.* 1039, is a very admirable invention for economizing vessels, lime, and fuel. The grate A, and fireplace, are separated from the evaporating laboratory D, by a double fire-bridge B, C, having an interstitial space in the middle, to arrest the communication of a melting or igniting heat towards the lead-lined cistern D. This cistern may be 8, 10, or 20 feet long, according to the magnitude of the soda work, and 4 feet or more wide. Its depth should be about 4 feet. It consists of sheet lead, of about 6 pounds weight to the square foot, and it is lined with one layer of bricks, set in Roman or hydraulic cement, both along the bottom and up the sides and ends. The lead comes up to the top of C, and the liquor, or ley, may be filled in to nearly that height. Things being thus arranged, a fire is kindled upon the grate A; the flame and hot air sweep along the surface of the liquor, raise its temperature there rapidly to the boiling point, and carry off the watery parts in vapor up the chimney E, which should be 15 or 20 feet high, to command a good draught. But, indeed, it will be most economical to build one high capacious chimney stalk, as is now done at Glasgow, Manchester, and Newcastle, and to lead the flues of the several furnaces above described into it. In this evaporating furnace the heavier and stronger ley goes to the bottom, as well as the impurities, where they remain undisturbed. Whenever the liquor has attained to the density of 1·3, or thereby, it is pumped up into evaporating cast-iron pans, of a flattened somewhat hemispherical shape, and evaporated to dryness while being diligently stirred with an iron rake and iron scraper.

1039



This alkali gets partially carbonated by the above surface-evaporating furnace, and is an excellent article.

When pure carbonate is wanted, that dry mass must be mixed with its own bulk of ground coal, sawdust, or charcoal, and thrown into a reverberatory furnace, like *fig.* 1038, but with the sole all upon one level. Here it must be exposed to a heat not exceeding 650° or 700° F.; that is, a little above the melting heat of lead; the only object being to volatilize the sulphur present in the mass, and carbonate the alkali. Now, it has been found, that if the heat be raised to distinct redness, the sulphur will not go off, but will continue in intimate union with the soda. This process is called calking, and the furnace is called a calker furnace. It may be six or eight feet long, and four or five feet broad in the hearth, and requires only one door in its side, with a hanging iron frame filled with a fire-tile or bricks, as above described.

This carbonating process may be performed upon several cwts. of the impure soda, mixed with sawdust, at a time. It takes three or four hours to finish the desulphuration; and it must be carefully turned over by the oar and the rake, in order to burn the coal into carbonic acid, and to present the carbonic acid to the particles of caustic soda diffused through the mass, so that it may combine with them.

When the blue flames cease, and the saline matters become white, in the midst of the coaly matter, the batch may be considered as completed. It is raked out, and when cooled, lixiviated in great iron cisterns with false bottoms, covered with mats. The watery solution being drawn off clear by a plug-hole, is evaporated either to dryness, in hemispherical cast-iron pans, as above described, or only to such a strength that it shows a pellicle upon its surface, when it may be run off into crystallizing cisterns of cast iron, or lead-lined wooden cisterns. The above dry carbonate is the best article for the glass manufacture.

Crystallized carbonate of soda contains 62⅞ per cent. of water. The crystals are colorless transparent rhomboids, which readily effloresce in the air, and melt in their own water of crystallization. On decanting the liquid from the fused mass, it is found that one part of the salt has given up its water of crystallization to another. By evaporation of that fluid, crystals containing one fifth less water than the common carbonate are obtained. These do not effloresce in the air.

Mineral soda, the sesquicarbonate (*Anderthalb kohlensaures natron*, Germ.), is found in the province of Sukena, in Africa, between Tripoli and Fezzan. It forms a stratum no more than an inch thick, just below the surface of the soil. Its texture is striated crystalline, like fibrous gypsum. Several hundred tons of it are collected annually, which are chiefly consumed in Africa. This species of soda does not effloresce like the Egyptian, or the manufactured soda crystals, owing to its peculiar state of composition and density. It was analyzed by Klaproth, under its native name of *trona*, and was found to consist, in 100 parts, of—soda, 37; carbonic acid, 38; sulphate of soda, 2·5; water, 22·5, in 100.

This soda is, therefore, composed of—3 atoms of carbonic acid, associated with 2 atoms of soda, and 4 of water; while our commercial soda crystals are composed of—1 atom of carbonic acid, 1 atom of soda, and 10 atoms of water.

There are six natron lakes in Egypt. They are situated in a barren valley, called Bahr-bela-ma, about thirty miles to the west of the Delta.

There are natron lakes also in Hungary, which afford in summer a white saline efflorescent crust of carbonate of soda, mixed with a little sulphate.

There are several soda lakes in Mexico, especially to the north of Zacatecas, as also in many other provinces. In Columbia, 48 English miles from Merida, mineral soda is extracted from the earth in great abundance, under the name of *urao*.

Bicarbonate of soda (*Doppelt kohlensaures natron*, Germ.), is prepared, like bicarbonate of potassa, by transmitting carbonic acid gas through a cold saturated solution of pure carbonate of soda, till crystalline crusts be formed. The bicarbonate may also be obtained in four-sided tables grouped together. It has an alkaline taste and reaction upon litmus paper, dissolves in 13 parts of cold water, and is converted by boiling water into the sesquicarbonate, with the disengagement of one fourth of its carbonic acid. It consists of—37 of soda, 52·35 carbonic acid, and 10·65 water.

SODA-WATER, is the name given to water containing a minute quantity of soda, and highly charged with carbonic acid gas, whereby it acquires a sparkling appearance, an agreeable pungent taste, an exhilarating quality, and certain medicinal powers. It constitutes a considerable object of manufacture in this kingdom. The following figure represents, I understand, the best system of apparatus for preparing it. A very dilute solution of soda is put into the globular vessel H, and the carbonic acid gas is forced into it from the gasometer F, by means of the powerful pump-work, as will be understood from the subjoined explanation.

The same apparatus may serve for making any species of aerated water, in imitation of any natural spring. All that is necessary for this purpose, is to put into the cistern Q, the neutro-saline matter, earths, metallic oxydes, pure water, &c., each in due proportion, according to the most accredited analysis of the mineral water to be imitated, to agitate that mixture, to suck it into the condenser H, through the pipe R, and then to impregnate it to the due degree, by pumping in the appropriate gas, previously contained in the gasometer F.

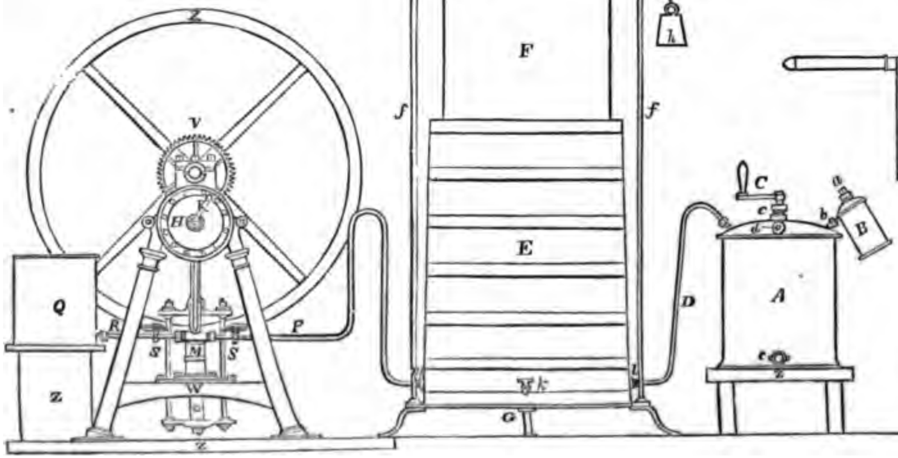
Thus, to make Seltzer water, for each 12 pounds troy, = 69,120 grains, or 1 gallon imperial very nearly, take 55 grains of dry carbonate of soda, 17 of carbonate of lime, 18 of carbonate of magnesia, 3½ of subphosphate of alumina, 3 of chloride of potassium, 155 of chloride of sodium, and 3 of finely precipitated silica. Put these materials into the cistern Q, and charge the gasometer F with 353 cubic inches of carbonic acid gas. Then work the machine by the handle of the wheel X, as explained below, and regulate the introduction of the liquid and the gas in aliquot portions; for example, if the condenser H admits half a gallon of water at a time, that quantity of liquid should be charged with 176 cubic inches of the gas, being one half of the whole quantity. The sulphureted mineral waters may be imitated in like manner, by taking the proportions of their constituents, as given in Table II. of WATERS, MINERAL.

IMPROVED SODA-WATER APPARATUS, AS MADE BY MR. HAYWARD TYLER, OF MILTON STREET.

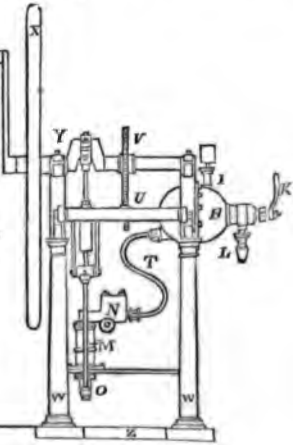
Fig. 1040, front view of the soda water machine. *Fig.* 1041, end view of the same.

A, lead generator, for making the gas. B, lead pot, for holding sulphuric acid. C, handle for moving the agitator of the receiver, which stirs up the ingredients in the lead generator. *a*, cap and screw, for charging the lead pot with sulphuric acid. *b*, swivel-joint, which is moveable, for occasionally throwing in portions of sulphuric acid for generating gas. *c*, stuffing-box for agitator. *d*, large cap and screw, for charging the lead generator with whiting and water. *e*, cap and screw, for emptying contents of ditto. D, lead pipe, to convey the gas from the lead generator to gasometer. E, wood tub, filled with water, for gasometer to work in. F, copper gasometer. G, strong iron frame, for gasometer and tub to stand on, firmly fixed together by three wrought-iron rods, *f*, *f*. *g*, *g*, two pulleys, for carrying rope and counterbalance weight *h*, for balancing copper gasometer. *i*, cock for discharging atmospheric air contained in the gasometer before making the gas. *k*, cock for occasionally emptying the water out of the tub. *l*, union joint, to which is fixed a copper pipe, passing through the water in the tub, to deliver the gas as generated into the copper gasometer. *m*, another union joint, with a similar copper pipe, passing through the water in the tub, and projecting two or three inches above the surface of the water, to convey the gas from the copper gasometer to the soda-water machine. H, H, condenser for aerating the soda-water. I, safety valve. K, K, bottling valve. L, bottling nipple. M, M, soda-water pump. N, valve-piece. O, O, piston of the pump. P, pipe for conducting gas from the gasometer to pump. Q, copper pan for holding the solution of soda. R, copper pipe for conducting the solution of soda to the force pump. S, S, two cocks for regulating the admission of the solution and gas to the pump. T, copper pipe through which the soda water is forced to the condenser. U, pinion wheel, to give motion to the agitator revolving inside the condenser. V, V, wheel for driving ditto. W, W, cast-iron frame for carrying machinery. X, X, cast-iron fly-wheel. Z, wrought iron crank. Y, Z, Z, wood stools and curb, upon which the whole of the machinery is fixed.

1040



1041



SODIUM, the metallic basis of soda, is obtained by processes similar to those by which potassium is procured. By fusing hydrate of soda with a little hydrate of potassa, a mixture is obtained, which yields more readily than soda by itself to the decomposing action of iron-turnings at a high heat, in a bent gun-barrel. The portion of potassium produced may be got rid of, by digesting the alloy for a few days in some naptha or oil of turpentine contained in an open vessel. The sodium remains at the bottom of the liquid. Pure sodium may, however, be prepared at once, by subjecting incinerated tartrate of soda to heat in the apparatus of Brunner, described under POTASSIUM. It is white, like silver; softer and more malleable than any other metal, and may be readily reduced into very thin leaves. It preserves its malleability till it approaches the melting point. Its specific gravity is 0·970. It softens at the temperature of 122° F., and at 200° it is perfectly fluid; but it will not rise in vapor until heated to nearly the melting point of glass. In the air it oxydizes slowly, and gets covered with a crust of soda; but it does not take fire till it is made nearly red-hot; and then it emits brilliant scintillations. When thrown upon water, it is rapidly oxydized, but without kindling, like potassium. If a drop of water be thrown upon it, it becomes so hot by the chemical action as to take fire. There are three oxydes of sodium; 1. the suboxyde; 2. the oxyde, or the basis of common soda; and, 3. the suroxyde; the last being formed when sodium is heated to redness upon a plate of silver.

SOLDERING (*Souder*, Fr.; *Löthen*, Germ.), is the process of uniting the surfaces of metals, by the intervention of a more fusible metal, which being melted upon each surface, serves, partly by chemical attraction, and partly by cohesive force, to bind them together. The metals thus united may be either the same or dissimilar; but the uniting metal must always have an affinity for both. Solders must be, therefore, selected in reference to their appropriate metals. Thus tin-plates are soldered with an alloy consisting of from 1 to 2 parts of tin, with 1 of lead; pewter is soldered with a more fusible alloy, containing a certain proportion of bismuth added to the lead and tin; iron, copper, and brass are soldered with spelter, an alloy of zinc and copper, in nearly equal parts; silver, sometimes with pure tin, but generally with silver-solder, an alloy consisting of 5 parts of silver, 6 of brass, and 2 of zinc; zinc and lead, with an alloy of from 1 to 2 parts of lead with 1 of tin; platinum, with fine gold; gold, with an alloy of silver and gold, or of copper and gold; &c.

In all soldering processes, the following conditions must be observed; 1. the surfaces to be united must be entirely free from oxyde, bright, smooth, and level; 2. the contact of air must be excluded during the soldering, because it is apt to oxydize one or other of the surfaces, and thus to prevent the formation of an alloy at the points of union. This exclusion of air is effected in various ways. The locksmith encases in loam the objects of iron, or brass, that he wishes to subject to a soldering heat; the silversmith and brasier mix their respective solders with moistened borax powder; the coppersmith and tinman apply sal ammoniac, rosin, or both, to the cleaned metallic surfaces, before using the soldering-iron to fuse them together with the tin alloy. The strong solder of the coppersmith consists of 8 parts of brass and 1 of zinc; the latter being added to the former, previously brought into a state of fusion. The crucible must be immediately covered up for two minutes till the combination be completed. The melted alloy is to be then poured out upon a bundle of twigs held over a tub of water, into which it falls in granulations. An alloy of 3 parts of copper and 1 of zinc forms a still stronger solder for the coppersmiths. When several parts are to be soldered successively upon the same piece, the more fusible alloys, containing more zinc, should be used first. A softer solder for coppersmiths is made with 6 parts of brass, 1 of tin, and 1 of zinc; the tin being first added to the melted brass, then the zinc; and the whole well incorporated by stirring.

The edges of sheet lead for sulphuric acid chambers, and its concentration pans, are joined together by melted lead itself, because any solder containing tin would soon be corroded. With this view, the two edges being placed in contact, are flattened down into a long wooden groove, and secured in their situation by a few brass pins driven into the wood. The surfaces are next brightened with a triangular scraper, rubbed over with candle grease, and then covered with a stream of hot melted lead. The riband of lead thus applied is finally equalized by being brought into partial fusion with the plumber's conical iron heated to redness; the contact of air being prevented by sprinkling rosin over the surface. The sheets of lead are thus *burned* together, in the language of the workmen.

SOOT (*Noir de fumée, Suie*, Fr.; *Rus, Flatterrus* Germ.), is the pulverulent charcoal condensed from the smoke of wood or coal fuel. A watery infusion of the former is said to be antiseptic, probably from its containing some creosote.

The soot of pitcoal has not been analyzed with any minuteness. It contains some sulphate and carbonate of ammonia, along with bituminous matter.

SORBIC ACID, is the same with malic acid; which see.

SOY, is a liquid condiment, or sauce, imported chiefly from China. It is prepared with a species of white haricots, wheat flour, common salt, and water; in the proportions respectively of 50, 60, 50, and 250 pounds. The haricots are washed, and boiled in water till they become so soft as to yield to the fingers. They are then laid in a flat dish to cool, and kneaded along with the flour, a little of the hot water of the decoction being added from time to time. This dough is next spread an inch or an inch and a half thick upon the flat vessel (made of thin staves of bamboo), and when it becomes hot and mouldy, in two or three days, the cover is raised upon bits of stick, to give free access of air. If a rancid odor is exhaled, and the mass grows green, the process goes on well; but if it grows black, it must be more freely exposed to the air. As soon as all the surface is covered with green mouldiness, which usually happens in eight or ten days, the cover is removed, and the matter is placed in the sunshine for several days. When it has become as hard as a stone, it is cut into small fragments, thrown into an earthen vessel, and covered with the 250 pounds of water having the salt dissolved in it. The whole is stirred together, and the height at which the water stands is noted. The vessel being placed in the sun, its contents are stirred up every morning and evening; and a cover is applied at night, to keep it warm and exclude rain. The more powerful the sun, the sooner the soy will be completed; but it generally requires two or three of the hottest summer months. As the mass diminishes by evaporation, well water is added; and the digestion is continued till the salt water has dissolved the whole of the flour and the haricots; after which the vessel is left in the sun for a few days, as the good quality of the soy depends on the completeness of the solution, which is promoted by regular stirring. When it has at length assumed an oily appearance, it is poured into bags, and strained. The clear black liquid is the soy, ready for use. It is not boiled, but is put up into bottles, which must be carefully corked. Genuine soy was made in this way at Canton, by Michael de Grubbens. See *Memoirs of Academy of Sciences of Stockholm* for 1803.

SPECIFIC GRAVITY, designates the relative weights of different bodies under the same bulk; thus a cubic foot of water weighs 1000 ounces avoirdupois; a cubic foot of coal, 1350; a cubic foot of cast iron, 7280; a cubic foot of silver, 10,400; and a cubic foot of pure gold, 19,200; numbers which represent the specific gravities of the respective substances, compared to water = 1·000. See ALLOY.

SPECULUM METAL, is an alloy of copper and tin; described under COPPER.

SPERMACETI; the *Cetine* of Chevreul. In certain species of the *cachalot* whale, as the *Physeter macrocephalus, tursio, microps,* and *orthodon*, as also the *Delphinus edentulus*, the fat of some parts of their bodies contains a peculiar kind of stearine, called spermaceti. The oil obtained from cavities in the bones of the cranium of the above cetaceæ is the richest in this kind of stearine. This being thrown into great filter-bags, the spermaceti oil passes through, and is subsequently purified by the addition of a small quantity of potash ley, which precipitates certain matters by neutralizing the acid that held them in solution. The solid which remains on the filter is next squeezed in bags, by means of a horizontal hydraulic press incased in steam, then digested with a weak potash ley, in order to dissolve out any oil which may continue to adhere to it, washed with water, finally dissolved in a tub by the agency of steam, laded into tin pans, and allowed slowly to concrete into a white, semi-transparent, brittle, lamellar crystalline mass, which forms elegant candles.

At 60° its specific gravity is 0·943. It melts at 112·5°; 100 parts of alcohol at 0·821 dissolve 3½ of it, of which 0·9 are deposited on cooling. Warm ether dissolves it in very large quantities. It is soluble also in the fat of volatile oils; and if the solutions have been saturated while hot, the greater part of the spermaceti crystallizes on cooling. When this substance has been purified by digesting alcohol upon it repeatedly, what remains is the *cetine* of Chevreul, or pure spermaceti. Its melting point has now become 116° F., and its boiling point 616° F., at which it distils without alteration. Caustic alkaline leys saponify it with difficulty.

SPIRIT OF AMMONIA is, properly speaking, alcohol combined with ammonia gas; but the term is often applied to water of ammonia.

SPIRITS, VINOUS. This subject has been fully discussed in the articles ALCOHOL, DISTILLATION, and FERMENTATION. I have shown that the progressive increase of alcohol in the wash tends progressively to prevent the conversion of the wort into spirit, or checks the fermenting process, though a great deal of fermentable matter remains unchanged. Mr. Sheridan has sought to remove this obstacle to the thorough transmutation of saccharine matter into alcohol, by drawing off the spirit as it is formed. For this purpose he ferments his wash in close tuns, connected with a powerful air-pump worked by machinery, thus continually removing the carbonic acid as it is formed, and maintaining a diminished pressure under which the alcohol readily distils at a temperature of 120° or 130° F. He finds that this degree of heat is not injurious to the fermentation, provided that it be communicated by the air of a stove-room, and not by water or steam pipes traversing the liquid, which would inevitably scald or seeth the particles in succession, and thereby extinguish the fermenting principle.

By the above ingenious plan, Mr. Sheridan tells me he has obtained 28 gallons of proof spirit from a quarter of grain, instead of the average product 21, being an increase of 25 per cent. The experiment was tried upon a considerable scale at Messrs. Currie's great distillery near London; but could not be established as a mode of manufacture, on account of the excise laws, which prohibit the distillers from carrying on the two processes of fermentation and distillation at the same time.

SPIRIT OF WINE; Alcohol.

SPONGE (*Eponge*, Fr.; *Schwamm*, Germ.), is a cellular fibrous tissue produced by small animals, almost imperceptible, called polypi by naturalists, which live in the sea. This tissue is said to be covered in its recent state with a kind of semi-fluid thin coat of animal jelly, susceptible of a slight contraction or trembling on being touched; which is the only symptom of vitality displayed by the sponge. After death, this jelly disappears, and leaves merely the sponge; formed by the combination of a multitude of small capillary tubes, capable of receiving water in their interior, and of becoming thereby distended. Sponges occur attached to stones at the bottom of the sea; and abound particularly upon the shores of the islands in the Grecian Archipelago. Although analogous in their origin to coral, sponges are quite different in their nature; the former being composed almost entirely of carbonate of lime; while the latter are formed of the same elements as animal matters, and afford, on distillation, a considerable quantity of ammonia.

Dilute sulphuric acid has been recommended for bleaching sponges, after the calcareous impurities have been removed by muriatic acid. Chlorine water answers better.

SPOON MANUFACTURE. See STAMPING OF METALS.

STAINED GLASS. When certain metallic oxydes or chlorides, ground up with proper fluxes, are painted upon glass, their colors fuse into its surface at a moderate heat, and make durable pictures, which are frequently employed in ornamenting the windows of churches as well as of other public and private buildings. The colors of stained glass are all transparent, and are therefore to be viewed only by transmitted light. Many metallic pigments, which afford a fine effect when applied cold on canvass or paper, are so changed by vitreous fusion as to be quite inapplicable to painting in stained glass.

The glass proper for receiving these vitrifying pigments, should be colorless, uniform, and difficult of fusion; for which reason crown glass, made with little alkali, or with kelp, is preferred. When the design is too large to be contained on a single pane, several are fitted together, and fixed in a bed of soft cement while painting, and then taken asunder to be separately subjected to the fire. In arranging the glass pieces, care must be taken to distribute the joinings so that the lead frame-work may interfere as little as possible with the effect.

A design must be drawn upon paper, and placed beneath the plate of glass; though the artist cannot regulate his tints directly by his palette, but by specimens of the colors producible from his palette pigments after they are fired. The upper side of the glass being sponged over with gum-water, affords, when dry, a surface proper for receiving the colors, without the risk of their running irregularly, as they would be apt to do, on the slippery glass. The artist first draws on the plate, with a fine pencil, all the traces which mark the great outlines and shades of the figures. This is usually done in black, or, at least, some strong color, such as brown, blue, green, or red. In laying on these, the painter is guided by the same principles as the engraver, when he produces the effect of light and shade by dots, lines, or hatches; and he employs that color to produce the shades, which will harmonize best with the color which is to be afterwards applied; but for the deeper shades, black is in general used. When this is finished, the whole picture will be represented in lines or hatches similar to an engraving finished up to the highest effect possible; and afterwards, when it is dry, the vitrifying colors are laid on by means of larger hair pencils; their selection being regulated by the burnt specimen tints. When he finds it necessary to lay two colors adjoining, which are apt to run together in the kiln, he must apply one of them to the back of the glass. But the few principal colors to be presently mentioned, are all fast colors, which do not run, except the yellow, which must therefore be laid on the opposite side. After coloring, the artist proceeds to bring out the lighter effects by taking off the color in the proper place, with a goose quill cut like a pen without a slit. By working this upon the glass, he removes the color from the parts where the lights should be the strongest; such as the hair, eyes, the reflection of bright surfaces and light parts of draperies. The blank pen may be employed either to make the lights by lines, or hatches and dots, as is most suitable to the subject.

By the metallic preparations now laid upon it, the glass is made ready for being fired, in order to fix and bring out the proper colors. The furnace or kiln best adapted for this purpose, is similar to that used by enamellers. See ENAMEL, and the *Glaze-kiln*, under POTTERY. It consists of a muffle or arch of fire-clay, or pottery, so set over a fireplace, and so surrounded by flues, as to receive a very considerable heat within, in the most equable and regular manner; otherwise some parts of the glass will be melted; while, on others, the superficial film of colors will remain unvitrified. The mouth of the muffle, and the entry for introducing fuel to the fire, should be on opposite sides, to prevent as much as possible the admission of dust into the muffle, whose mouth should be closed with double folding-doors of iron, furnished with small peep-holes, to allow the artist to watch the progress of the staining, and to withdraw small trial slips of glass, painted with the principal tints used in the picture.

The muffle must be made of very refractory fire-clay, flat at its bottom, and only 5 or 6 inches high, with such an arched top as may make the roof strong, and so close on all sides as to exclude entirely the smoke and flame. On the bottom of the muffle a smooth bed of sifted lime, freed from water, about half an inch thick, must be prepared for receiving the pane of glass. Sometimes several plates of glass are laid over each other with a layer of dry pulverulent lime between each. The fire is now lighted, and most gradually raised, lest the glass should be broken; and after it has attained to its full heat, it must be kept up for 3 or 4 hours, more or less, according to the indications of the trial slips; the yellow color being principally watched, as it is found to be the best criterion of the state of the others. When the colors are properly burnt in, the fire is suffered to die away, so as to anneal the glass.

STAINED-GLASS PIGMENTS.

Flesh color.—Take an ounce of red lead, 2 ounces of red enamel, (Venetian glass enamel, from alum and copperas calcined together,) grind them to fine powder, and work this up with spirits (alcohol) upon a hard stone. When slightly baked, this produces a fine flesh color.

Black color.—Take 14½ ounces of smithy scales of iron, mix them with two ounces of white glass, (crystal,) an ounce of antimony, and half an ounce of manganese; pound and grind these ingredients together with strong vinegar. A brilliant black may also be obtained by a mixture of cobalt blue with the oxydes of manganese and iron. Another black is made from three parts of crystal glass, two parts of oxyde of copper, and one of (glass of) antimony worked up together, as above.

Brown color.—An ounce of white glass or enamel, half an ounce of good manganese; ground together.

Red, rose, and brown colors, are made from peroxyde of iron, prepared by nitric acid. The flux consists of borax, sand, and minium in small quantity.

Red color, may be likewise obtained from one ounce of red chalk pounded, mixed with two ounces of white hard enamel, and a little peroxyde of copper.

A red, may also be composed of rust of iron, glass of antimony, yellow glass of lead, such as is used by potters, (or litharge,) each in equal quantity; to which a little sulphuret of silver is added. This composition, well ground, produces a very fine red color on glass. When protoxyde of copper is used to stain glass, it assumes a bright red or green color, according as the glass is more or less heated in the furnace, the former corresponding to the orange protoxyde, the latter having the copper in the state of peroxyde.

Bistres and brown reds, may be obtained by mixtures of manganese, orange oxyde of copper, and the oxyde of iron called umber, in different proportions. They must be previously fused with vitreous solvents.

Green color.—Two ounces of brass calcined into an oxyde, two ounces of minium, and eight ounces of white sand; reduce them to a fine powder, which is to be enclosed in a well luted crucible, and heated strongly in an air-furnace for an hour. When the mixture is cold, grind it in a brass mortar. Green may, however, be advantageously produced by a yellow on one side, and a blue on the other. Oxyde of chrome has been also employed to stain glass green.

A fine yellow color.—Take fine silver laminated thin, dissolve in nitric acid, dilute with abundance of water, and precipitate with solution of sea salt. Mix this chloride of silver, in a dry powder, with three times its weight of pipe-clay well burnt and pounded. The back of the glass pane is to be painted with this powder; for when painted on the face, it is apt to run into the other colors.

Another yellow can be made by mixing sulphuret of silver with glass of antimony, and yellow ochre previously calcined to a red-brown tint. Work all these powders together, and paint on the back of the glass. Or silver *laminæ* melted with sulphur, and glass of antimony, thrown into cold water, and afterwards ground to powder, afford a yellow.

A pale yellow may be made with the powder resulting from brass, sulphur, and glass of antimony, calcined together in a crucible, till they cease to smoke; and then mixed with a little burnt yellow ochre.

The fine yellow of M. Merand is prepared from chloride of silver, oxyde of zinc, white-clay, and rust of iron. This mixture, simply ground, is applied on the glass.

Orange color.—Take 1 part of silver powder, as precipitated from the nitrate of that metal by plates of copper, and washed; mix it with 1 part of red ochre and 1 of yellow, by careful trituration; grind into a thin pap with oil of turpentine or lavender, and apply this with a brush, dry, and burn in.

In the Philosophical Magazine, of December, 1836, the anonymous author of an ingenious essay, "On the Art of Glass-painting," says, that if a large proportion of ochre has been employed with the silver, the stain is yellow; if a small proportion, it is orange-colored; and by repeated exposure to the fire, without any additional coloring-matter, the orange may be converted into red; but this conversion requires a nice management of the heat. Artists often make use of panes colored throughout their substance in the glass-house pots, because the perfect transparency of such glass gives a brilliancy of effect, which enamel painting, always more or less opaque, cannot rival. It was to a glass of this kind that the old glass-painters owed their splendid red. This is, in fact, the only point in which the modern and ancient processes differ; and this is the only part of the art which was ever really lost. Instead of blowing plates of solid red, the old glass-makers (like those of Bohemia, for some time back) used to *flash* a thin layer of brilliant red over a substratum of colorless glass; by gathering a lump of the latter upon the end of their iron rod in one pot, covering it with a layer of the former in another pot, then blowing out the two together into a globe or cylinder, to be opened into circular tables, or into rectangular plates. The elegant art of tinging glass red by protoxyde of copper, and flashing it on common crown glass, has become general within these few years.

That gold melted with flint glass stains it purple, was originally discovered and practised, as a profitable secret, by Kunckel. Gold has been recently used at Birmingham for giving a beautiful rose-color to scent bottles. The proportion of gold should be very small, and the heat very great, to produce a good effect. The glass must contain either the oxyde of lead, bismuth, zinc, or antimony; for crown glass will take no color from gold. Glass combined with this metal, when removed from the crucible, is generally of a pale rose-color; nay, sometimes is as colorless as water, and does not assume its ruby color till it has been exposed to a low red heat, either under a muffle or at the lamp. This operation must be nicely regulated; because a slight excess of fire destroys the color, leaving the glass of a dingy brown, but with a blue (green ?) transparency, like that of gold leaf. It is metallic gold which gives the color; and, indeed, the oxyde is too easily reduced, not to be converted into the metal by the intense heat which is necessarily required.

Upon the kindred art of painting in enamel, Mr. A. Essex has published an interesting paper in the same journal, for June, 1837, in which he says that the ancient ruby glass, on being exposed to the heat of a glass-kiln, preserves its color unimpaired, while the modern suffers considerable injury, and in some cases becomes almost black. Hence the latter cannot be painted upon, as the heat required to fix the fresh color would destroy the beauty of the original basis. To obviate this difficulty, the artist paints upon a piece of plain glass the tints and shadows necessary for blending the rich ruby glow with the other parts of his picture, leaving those parts untouched where he wishes the ruby to appear in undiminished brilliancy, and fixes the ruby glass in the picture behind the painted piece, so that in such parts the window is double glazed. Mr. Essex employs, as did the late Mr. Muss, chrome oxyde alone for greens; and he rejects the use of iron and manganese in his enamel colors.

Colored transparent glass is applied as enamel in silver and gold *bijouterie*, previously *bright-cut* in the metal with the graver or the rose-engine. The cuts, reflecting the rays of light from their numerous surfaces, exhibit through the glass, richly stained with gold, silver, copper, cobalt, &c., a gorgeous play of prismatic colors, varied with every change of aspect. When the enamel is to be painted on, it should be made opalescent by oxyde of arsenic, in order to produce the most agreeable effect.

The artist in enamel has obtained from modern chemistry, preparations of the metals platinum, uranium, and chromium, which furnish four of the richest and most useful colors of his palette. Oxyde of platinum produces a substantive rich brown, formerly unknown in enamel painting; a beautiful transparent tint, which no intensity or repetition of fire can injure. Colors proper for enamel painting, he says, are not to be purchased; those sold for the purpose, are adapted only for painting upon china. The constituents of the green enamel used by his brother, Mr. W. Essex, are, silica, borax, oxyde of lead, and oxyde of chrome.

Mr. Essex's enamelling furnace is a cubic space of about 12 inches, and contains a fire-clay muffle, without either bottom or back, which is surrounded with coke, except in front. The entire draught of air which supplies the furnace, passes through the muffle; the plates and paintings being placed on a thin slab, made of tempered fire-clay, technically termed *planche*, which rests on the bed of coke-fuel. As the greatest heat is at the back of the muffle, the picture must be turned round while in the fire, by means of a pair of spring tongs. The above furnace serves for objects up to five inches in diameter; but for larger works a different furnace is required, for the description of which I must refer to the original paper.

Relatively to the receipts for enamel colors, and for staining and gilding on glass, for which twenty guineas were voted by the Society for the Encouragement of Arts, in the session of 1817, to Mr. R. Wynn, Mr. A. Essex says, in p. 446 of his essay—"the unfortunate artist who shall attempt to make colors for the purpose of painting in enamel from these receipts, will assuredly find, to his disappointment, that they are utterly useless." In page 449 he institutes a comparison between Mr. Wynn's complex farrago for green, as published in the Transactions of the Society, with the simple receipt of his brother, as given above. It is a remarkable circumstance, that not one of our enamel artists, during a period of twenty years, should have denounced the fallacy of these receipts, and the folly of sanctioning imposture by a public reward. Should Mr. Essex's animadversions be just, the well-intentioned Society in the Adelphi may, from the negligence of its committee, come to merit the *sobriquet*, "For the Discouragement of Arts."

STAMPING OF METALS. The following ingenious machine for manufacturing metal spoons, forks, and other articles, was made the subject of a patent by Jonathan Hayne, of Clerkenwell, in May, 1833. He employs a stamping-machine with dies, in which the hammer is raised to a height between guides, and is let fall by a trigger. He prefers fixing the protuberant or relief portion of the die to the stationary block or bed of the stamping-machine, and the counterpart or intaglio to the falling hammer or ram.

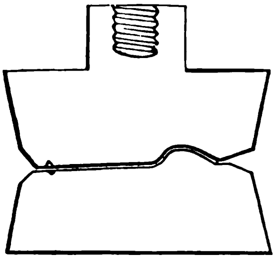
The peculiar feature of improvement in this manufacture consists in producing the spoon, ladle, or fork perfect at one blow in the stamping-machine, and requiring no further manipulation of shaping, but simply trimming off the barb or fin, and polishing the surface, to render the article perfect and finished.

Heretofore, in employing a stamping-machine, or fly-press, for manufacturing spoons, ladles, and forks, it has been the practice to give the impressions to the handles, and to the bowls or prongs, by distinct operations of different dies, and after having so partially produced the pattern upon the article, the handles had to be bent and formed by the operations of filing and hammering.

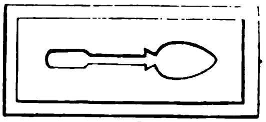
By his improved form of dies, which, having curved surfaces and bevelled edges, allow of no parts of the faces of the die and counter-die to come into contact, he is enabled to produce considerable elevations of pattern and form, and to bring up the article perfect at one blow, with only a slight barb or fin upon its edge.

In the accompanying drawings, *fig.* 1042 is the lower or bed die for producing a spoon, seen edgewise; *fig.* 1043 is the face of the upper or counter-die, corresponding; *fig.* 1044 is a section, taken through the middle of the pair of dies, showing the space in which the metal is pressed to form the spoon.

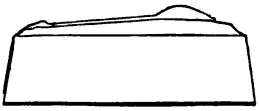
1044



1043



1042

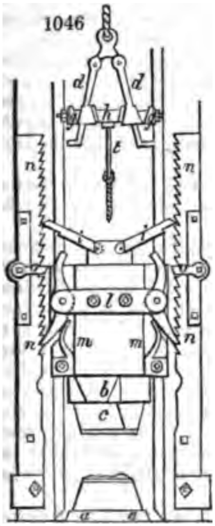


To manufacture spoons, ladles, or forks according to his improved process, he first forges out the ingot into flat pieces, of the shape and dimensions of the die of the intended article; and if a spoon or ladle is to be made, gives a slight degree of concavity to the bowl part; but, if necessary, bends the back, in order that it may lie more steadily, and bend more accurately, upon the lower die; if a fork, he cuts or otherwise removes portions of the metal at those parts which will intervene between the prongs; and, having thus produced the rude embryo of the intended article, scrapes its entire surface clean and free from oxydation-scale or fire-strain, when it is ready to be introduced into the stamping-machine.

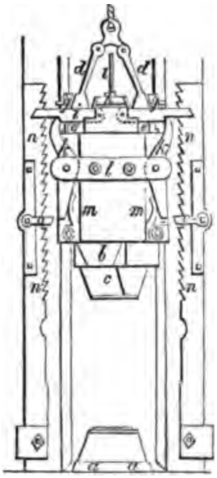
He now fixes the lower die in the bed of the stamping-machine, shown at *a*, *a*, in the elevations *figs.* 1045 and 1046, and fixes, in the hammer *b*, the upper or counter-die c, accurately adjusting them both, so that they may correspond exactly when brought together. He then places the rudely-formed article above described upon the lower die, and having drawn up the hammer to a sufficient elevation by a windlass and rope, or other ordinary means, lets go the trigger, and allows the hammer with the counter-die to fall upon the under die, on which the article is placed; when, by the blow thus given to the metal, the true and perfect figure and pattern of the spoon, ladle, or fork is produced, and which, as before said, will only require the removal of the slight edging of barb or fin, with polishing, to finish it.

On striking the blow, in the operation of stamping the article, the hammer will recoil and fly up some distance, and if allowed to fall again with reiterated blows, would injure both the article and the dies; therefore, to avoid this inconvenience, he causes the hammer on recoiling to be caught by a pair of palls locking into racks on the face of the standards, seen in *figs.* 1045 and 1046. In *fig.* 1045 the hammer *b*, of the stamping-machine, is seen raised and suspended by a rope attached to a pair of jointed hooks or holders *d*, *d*, the lower ends of which pass into eyes *e*, *e*, extending from the top of the hammer. When the lever or trigger *t* is drawn forward, as in *fig.* 1046, the two inclined planes *g*, *g*, on the axle *h*, press the two legs of the holders *d*, *d*, inward, and cause their hooks or lower ends to be withdrawn from the eyes *e*, *e*, when the hammer instantly falls, and brings the dies together: such is the ordinary construction of the stamping-machine.

1046



1045



On the hammer falling from a considerable elevation, the violence of the blow causes it to recoil and bound upwards, as before mentioned; it therefore becomes necessary to catch the hammer when it has rebounded, in order to prevent the dies coming again together; this is done by the following mechanism:—

Two latch levers *i*, *i*, are connected by joints to the upper part of the hammer, and two pall levers *k*, *k*, turning upon pins, are mounted in the bridge *l*, affixed to the hammer. Two springs *m*, *m*, act against the lower arms of these levers, and press them outwards, for the purpose of throwing the palls at the lower ends of the levers into the teeth of the ratchet racks *n*, *n*, fixed on the sides of the upright standards.

Previously to raising the hammer, the upper ends of the pall levers *k*, are drawn back, and the latches *i*, being brought down upon them, as in *fig.* 1045, the levers *k* are confined, and their palls prevented from striking into the side racks; but as the hammer falls, the ends of the latches *i* strike upon the fingers *o*, *o*, fixed to the side standards, and liberate the palls, the lower ends of which, when the hammer rebounds, after stamping, catch into the teeth of the racks, as in *fig.* 1046, and thereby prevent the hammer from again descending.

STARCH (*Amidon*, *Fecule*, Fr; *Stärke*, Germ.), is a white pulverulent substance, composed of microscopic spheroids, which are bags containing the amylaceous matter. It exists in a great many different plants, and varies merely in the form and size of its microscopic particles; as found in some plants, it consists of spherical particles $\frac{1}{1000}$ of an inch in diameter; and in others, of ovoid particles, of $\frac{1}{300}$ or $\frac{1}{400}$ of an inch. It occurs, 1. in the seeds of all the acotyledinous plants, among which are the several species of corns, and those of other *gramineæ*; 2. in the round perennial tap roots, which shoot up an annual stem; in the tuberose roots, such as potatoes, the *Convolvulus batatas* and *edulis*, the *Helianthus tuberosus*, the *Jatropha manihot*, &c., which contain a great quantity of it; 3. in the stems of several monocotyledinous plants, especially of the palm tribe, whence sago comes; but it is very rarely found in the stems and branches of the dicotyledinous plants; 4. it occurs in many species of lichen. Three kinds of starch have been distinguished by chemists; that of wheat, that called *inuline*, and lichen starch. These three agree in being insoluble in cold water, alcohol, ether, and oils, and in being converted into sugar by either dilute sulphuric acid or diastase. The main difference between them consists in their habitudes with water and iodine. The first forms with hot water a mucilaginous solution, which constitutes, when cold, the paste of the laundress, and is tinged blue by iodine; the second forms a granular precipitate, when its solution in boiling-hot water is suffered to cool, which is tinged yellow by iodine; the third affords, by cooling the concentrated solution, a gelatinous mass, with a clear liquor floating over it, that contains little starch. Its jelly becomes brown-gray with iodine.

1. *Ordinary starch.*—This may be extracted from the following grains:—wheat, rye, barley, oats, buckwheat, rice, maize, millet, spelt; from the siliquose seeds, as peas beans, lentiles, &c.; from tuberous and tap roots, as those of the potato, the orchis, manioc, arrow-root, batata, &c. Different kinds of corn yield very variable quantities of starch. Wheat differs in this respect, according to the varieties of the plant, as well as the soil manure, season, and climate. See BREAD.

Wheat partly damaged by long keeping in granaries, may be employed for the manufacture of starch, as this constituent suffers less injury than the gluten; and it may be used either in the ground or unground state.

1. *With unground wheat.*—The wheat being sifted clean, is to be put into cisterns, covered with soft water, and left to steep till it becomes swollen and so soft as to be easily crushed between the fingers. It is now to be taken out, and immersed in clear water of a temperature equal to that of malting-barley, whence it is to be transferred into bags, which are placed in a wooden chest containing some water, and exposed to strong pressure. The water rendered milky by the starch being drawn off by a tap, fresh water is poured in, and the pressure is repeated. Instead of putting the swollen grain into bags, some prefer to grind it under vertical edge-stones, or between a pair of horizontal rollers, and then to lay it in a cistern, and separate the starchy liquor by elutriation with successive quantities of water well stirred up with it. The residuary matter in the sacks or cisterns contains much vegetable albumen and gluten, along with the husks; when exposed to fermentation, it affords a small quantity of starch of rather inferior quality.

The above milky liquor, obtained by expression or elutriation, is run into large cisterns, where it deposites its starch in layers successively less and less dense; the uppermost containing a considerable proportion of gluten. The supernatant liquor being drawn off, and fresh water poured on it, the whole must be well stirred up, allowed again to settle, and the surface-liquor again withdrawn. This washing should be repeated as long as the water takes any perceptible color. As the first turbid liquor contains a mixture of gluten, sugar, gum, albumen, &c., it ferments readily, and produces a certain portion of vinegar, which helps to dissolve out the rest of the mingled gluten, and thus to bleach the starch. It is, in fact, by the action of this fermented or soured water, and repeated washing, that it is purified. After the last deposition and decantation, there appears on the surface of the starch a thin layer of a slimy mixture of gluten and albumen, which, being scraped off, serves for feeding pigs or oxen; underneath will be found a starch of good quality. The layers of different sorts are then taken up with a wooden shovel, transferred into separate cisterns, where they are agitated with water, and passed through fine sieves. After this pap is once more well settled, the clear water is drawn off, the starchy mass is taken out, and laid on linen cloths in wicker baskets, to drain and become partially dry. When sufficiently firm, it is cut into pieces, which are spread upon other cloths, and thoroughly desiccated in a proper drying-room, which in winter is heated by stoves. The upper surface of the starch is generally scraped, to remove any dusty matter, and the resulting powder is sold in that state. Wheat yields, upon an average, only from 35 to 40 per cent. of good starch. It should afford more by skilful management.

2. In this country, wheat crushed between iron rollers is laid to steep in as much water as will wet it thoroughly; in four or five days the mixture ferments, soon afterwards settles, and is ready to be washed out with a quantity of water into the proper fermenting vats. The common time allowed for the steep, is from 14 to 20 days. The next process consists in removing the stuff from the vats into a stout round basket set across a back below a pump. One or two men keep going round the basket, stirring up the stuff with strong wooden shovels, while another keeps pumping water, till all the *farina* is completely washed from the bran. Whenever the subjacent back is filled, the liquor is taken out and strained through hair sieves into square frames or cisterns, where it is allowed to settle for 24 hours; after which the water is run off from the deposited starch by plug taps at different levels in the side. The thin stuff called *slimes*, upon the surface of the starch, is removed by a tray of a peculiar form. Fresh water is now introduced, and the whole being well mixed by proper agitation, is then poured upon fine silk sieves. What passes through is allowed to settle for 24 hours; the liquor being withdrawn, and then the slimes, as before, more water is again poured in, with agitation, when the mixture is again thrown upon the silk sieve. The milky liquor is now suffered to rest for several days, 4 or 5, till the starch becomes settled pretty firmly at the bottom of the square cistern. If the starch is to have the blue tint,

called Poland, fine smalt must be mixed in the liquor of the last sieve, in the proportion of two or three pounds to the cwt. A considerable portion of these slimes may, by good management, be worked up into starch by elutriation and straining.

The starch is now fit for *boxing*, by shovelling the cleaned deposite into wooden chests, about 4 feet long, 12 inches broad, and 6 inches deep, perforated throughout, and lined with thin canvass. When it is drained and dried into a compact mass, it is turned out by inverting the chests upon a clean table, where it is broken into pieces four or five inches square, by laying a ruler underneath the cake, and giving its surface a cut with a knife, after which the slightest pressure with the hand will make the fracture. These pieces are set upon half-burned bricks, which by their porous capillarity imbibe the moisture of the starch, so that its under surface may not become hard and horny. When sufficiently dried upon the bricks, it is put into a stove, (which resembles that of a sugar refinery,) and left there till tolerably dry. It is now removed to a table, when all the sides are carefully scraped with a knife; it is next packed up in the papers in which it is sold; these packages are returned into the stove, and subjected to a gentle heat during some days; a point which requires to be skilfully regulated.

Mr. Samuel Hall obtained a patent for bleaching starch by chloride of lime in 1821. Chlorine water would probably be preferable, and might prove useful in operating upon damaged wheat.

The sour water of the starch manufacture contains, according to Vauquelin, acetic acid, acetate of ammonia, alcohol, phosphate of lime, and gluten.

During the drying, starch splits into small prismatic columns, of considerable regularity. When kept dry, it remains unaltered for a very long period. When it is heated to a certain degree in water, the envelopes of its spheroidal particles burst, and the *farina* forms a mucilaginous emulsion, magma, or paste. When this apparent solution is evaporated to dryness, a brittle horny-looking substance is obtained, quite different in aspect from starch, but similar in chemical habitudes. When the moist paste is exposed for two or three months to the air in summer, the starch is converted into sugar to the amount of one third or one half of its weight, into gum, and gelatinous starch called *amidine* by De Saussure, with occasionally a resinous matter. This curious change goes on even in close vessels.

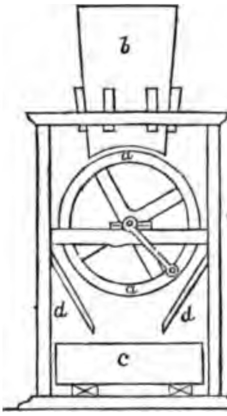
Starch from potatoes.—From the following table of analyses, it appears that potatoes contain from 24 to 30 per cent. of dry substance:—

	Starch.	Fibrous Parenchyma.	Vegetable Albumen	Gum, Sugar, and Salts.	Water.
Red potatoes, - - - -	15·0	7·0	1·4	9·2	75·0
Germinating potatoes, - -	15·2	6·8	1·3	3·7	73·0
Kidney potatoes, - - -	9·1	8·8	0·8	—	81·3
Large red potatoes, - -	12·9	6·0	0·7	—	78·0
Sweet potatoes, - - -	15·1	8·2	0·8	—	74·3
Peruvian potatoes, - -	15·0	5·2	1·9	1·9	76·0
English potatoes, - - -	12·9	6·8	1·1	1·7	77·5
Parisian potatoes, - -	13·3	6·8	0·9	4·8	73·1

Manufacture of potato starch.—The potatoes are first washed in a cylindrical cage formed of wooden spars, made to revolve upon a horizontal axis, in a trough filled with water to the level of the axis. They are then reduced to a pulp by a rasping machine, similar to that represented in *figs.* 1047, 1048, where *a* is a wooden drum covered with sheet-iron, roughened outside with numerous prominences, made by punching out holes from the opposite side. It is turned by a winch fixed upon each end of the shaft. The drum is enclosed in a square wooden box, to prevent the potato-mash from being scattered about. The hopper *b* is attached to the upper frame, has its bottom concentric with the rasp-drum, and nearly in contact with it. The pulp chest *c* is made to slide out, so as when full to be readily replaced by another. The two slanting boards *d*, *d*, conduct the pulp into it. A moderate stream of water should be made to play into the hopper upon the potatoes, to prevent the surface of the rasp from getting foul with fibrous matter. Two men, with one for a relay, will rasp, with such a machine, from 2½ to 3 tons of potatoes in 12 hours.

The potato pulp must be now elutriated upon a fine wire or hair seive, which is set upon a frame in the mouth of a large vat, while water is made to flow upon it from a spout with many jets. The pulp meanwhile must be stirred and kneaded by the hand, or by a mechanical brush-agitator, till almost nothing but fibrous particles are left upon the sieve. These, however, generally retain about five per cent. of starch, which cannot be separated in this way. This parenchyma should therefore be subjected to a separate rasping upon another cylinder. The water turbid with starch is allowed to settle for some

1047



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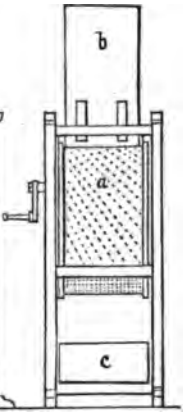


time in a back; the supernatant liquor is then run by a cock into a second back, and after some time into a third, whereby the whole starch will be precipitated. The finest powder collects in the last vessel. The starch thus obtained, containing 33 per cent. of water, may be used either in the moist state, under the name of *green fecula*, for various purposes, as for the preparation of dextrine, and starch sirup; or it may be preserved under a thin layer of water, which must be renewed from time to time, to prevent fermentation; or lastly, it may be taken out and dried.

In trials made with St. Etienne's rasp and starch machinery, in Paris, which was driven by two horses, nearly 18 cwts. of potatoes were put through all the requisite operations in one hour, including the pumping of the water. The product in starch amounted to from 17 to 18 per cent. of the potatoes. The quicker the process of potato-starch making, the better is its quality.

Starch from certain foreign plants.—1. From the pith of the *sago palm.* See SAGO.

2. From the roots of the *Maranta arundinacea*, of Jamaica, the Bahamas, and other West India islands, the powder called arrow-root is obtained, by a process analogous to that for making potato starch.

3. From the root of the *Manioc*, which also grows in the West Indies, as well as in Africa, the *cassava* is procured by a similar process. The juice of this plant is poisonous, from which the wholesome starch is deposited. When dried with stirring upon hot iron plates, it agglomerates into small lumps, called *tapioca ;* being a gummy fecula.

The characters of the different varieties of starch can be learned only from microscopic observation; by which means also their sophistication or admixture may be readily ascertained.

Starch, from whatever source obtained, is a white soft powder, which feels crispy, like flowers of sulphur, when pressed between the fingers; it is destitute of taste and smell, unchangeable in the atmosphere, and has a specific gravity of 1·53. I have already described the particles as spheroids enclosed in a membrane. The potato contains some of the largest, and the millet the smallest. Potato starch consists of truncated ovoids, varying in size from $\frac{1}{300}$ to $\frac{1}{3000}$ of an inch; arrow-root, of ovoids varying in size from $\frac{1}{800}$ to $\frac{1}{2000}$ of an inch; flower starch, of insulated globules about $\frac{1}{1000}$ of an inch; cassava, of simular globules assembled in groups. These measurements I have made with a good achromatic microscope, and a divided glass-slip micrometer of Tully.

For the saccharine changes which starch undergoes by the action of *diastase*, see FERMENTATION.

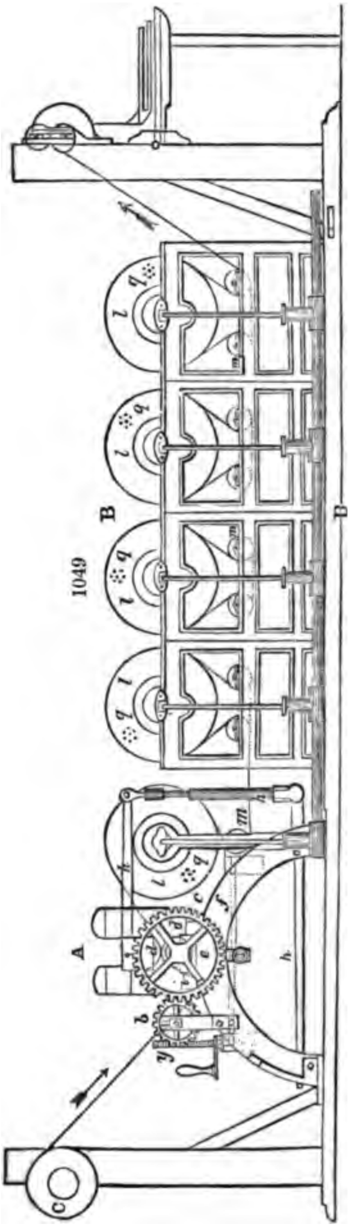
Lichenine, a species of starch obtained from Iceland moss, (*Cetraria islandica*,) as well as *inuline*, from elecampane, (*Inula Helenium*,) are rather objects of chemical curiosity, than of manufactures.

There is a kind of starch made in order to be converted into gum for the calico-printer. This conversion having been first made upon the great scale in this country, has occasioned the product to be called British gum. The following is the process pursued in a large and well conducted establishment near Manchester. A range of four wooden cisterns, each about 7 or 8 feet square, and 4 feet deep, is provided. Into each of them 2000 gallons of water being introduced, 12½ loads of flour are stirred in. This mixture is set to ferment upon old leaven left at the bottom of the backs, during 2 or 3 days. The contents are then stirred up, and pumped off into 3 stone cisterns, 7 feet square and 4 feet deep; as much water being added, with agitation, as will fill the cisterns to the brim. In the course of 24 hours the starch forms a firm deposite at the bottom; and the water is then syphoned off. The gluten is next scraped from the surface, and the starch is transferred into wooden boxes pierced with holes, which may be lined with coarse cloth, or not, at the pleasure of the operator.

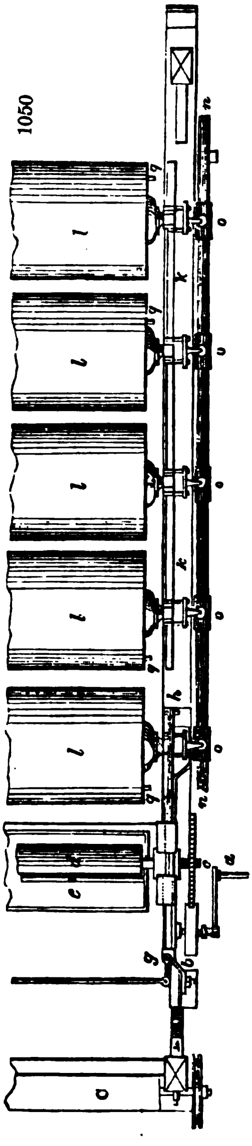
The starch, cut into cubical masses, is put into iron trays, and set to dry in a large apartment, two stories high, heated by a horizontal cylinder of cast iron traversed by the flame of a furnace. The drying occupies two days. It is now ready for conversion into gum, for which purpose it is put into oblong trays of sheet iron, and heated to the temperature of 300° F. in a cast-iron oven, which holds four of these trays. Here it concretes into irregular semi-transparent yellow-brown lumps, which are ground into fine flour between mill-stones, and in this state brought to the market. In this roasted starch, the vesicles being burst, their contents become soluble in cold water. British gum is not convertible into sugar, as starch is, by the action of dilute sulphuric acid; nor into mucic acid, by nitric acid; but into the oxalic; and it is tinged purple-red by iodine. It is composed, in 100 parts, of 35·7 carbon, 6·2 hydrogen, and 58·1 oxygen; while starch is composed of, 43·5 carbon, 6·8 hydrogen, and 49·7 oxygen.

To prove whether starch be quite free from gluten, or whether it be mixed with any wheat flour, diffuse 12 grains of it through six ounces of water, heat the mixture to boiling, stirring it meanwhile with a glass slip. If the starch be pure, no froth will be seen upon the surface of the pasty fluid; or if any be produced during the stirring, it will immediately subside after it; but if the smallest portion of gluten be present, much froth will be permanently formed, which may be raised by stirring into the appearance of soap-suds.

1049



1050



STARCHING AND STEAM-DRYING APPARATUS. The system of hollow cylinders, for drying goods in the processes of bleaching or calico-printing, is represented in *fig.* 1049, in a longitudinal section, and in *fig.* 1050, in a top view; but the cylinders are supposed to be broken off in the middle, as it was needless to repeat the parts at the other end, which are sufficiently shown in the section.

A is the box containing the paste, when the goods are to be starched or stiffened; *a*, a winch, when it is desired to turn the machine by hand, though it is always moved by power in considerable factories; *b*, is the driving pinion; *d*, *d'*, two brass rollers with iron shafts, the undermost of which is moved by the wheel *c*, in gear with the pinion *b*. The uppermost roller *d'*, is turned by the friction with the former, *d*, being pressed upon it by the weighted lever *h*; *e* is the trough filled with the paste, which rests upon the bars *f*, and may be placed higher or lower by means of the adjusting screws *g*, according as the roller *d* is to be plunged more or less deeply. A brass roller *i* serves to force down the cloth into the paste.

B, is the drying part of the machine; *k*, *k*, its iron framing; *l*, *l*, &c., five drums, or hollow copper cylinders, heated with steam; *m*, *m*, *m*, &c., small copper drums, in pairs, turning freely on shafts under the former, for stretching the goods, and airing them, during their passage through the machine; *n*, *n*, is the main steam-pipe, from which branch off small copper tubes, *o*, *o*, &c., which conduct the steam through stuffing-boxes into the cavity of the drying-drums. There are similar tubes upon the other ends of the drums, for discharging the condensed water through similar stuffing-boxes; *q*, *q*, are valves, opening internally, for admitting the air whenever the steam is taken off, or becomes feeble, to prevent the drums from being crushed by the unbalanced pressure of the atmosphere upon their external surfaces.

C, is the cloth-beam, from which the starching roller draws forward the goods; D, are two rollers, of which the lower is provided with a band-pulley or rigger, driven by a similar pulley fixed upon the shaft of the starching roller *d*. These two rollers pull the goods through the drying machine, and then let them fall either upon a table or the floor.

STEAM, is the vapor of hot water; the discussion of which belongs to chemistry, physics, and engineering. Certain practical applications of the subject will be found in the article EVAPORATION.

STEARIC ACID, improperly called STEARINE (*Talgsaüre*, Germ.), is the solid constituent of fatty substances, as of tallow and olive oil, converted into a crystalline mass by saponification with alkaline matter, and abstraction of the alkali by an acid. By this process, fats are convertible into three acids, called Stearic, Margaric, and Oleic; the first two being solid, and the last liquid. The stearine, of which *factitious wax* candles are made, consists of the stearic and margaric acids combined. These can be separated from each other only by the agency of alcohol, which holds the margaric acid in solution after it has deposited the stearic in crystals. Pure stearic acid is prepared, according to its discoverer, Chevreul, in the following way:—Make a soap, by boiling a solution of potash and mutton-suet in the proper equivalent proportions (see SOAP); dissolve one part of that soap in 6 parts of hot water, then add to the solution 40 or 50 parts of cold water, and set the whole into a place whose temperature is about 52° Fahrenheit. A substance falls to the bottom, possessed of pearly lustre, consisting of the bi-stearate and bi-margarate of potash; which is to be drained and washed upon a filter. The filtered liquor is to be evaporated, and mixed with the small quantity of acid necessary to saturate the alkali left free by the precipitation of the above bi-salts. On adding water to it afterwards, the liquor affords a fresh quantity of bi-stearate and bi-margarate. By repeating this operation with precaution, we finally arrive at a point when the solution contains no more of these solid acids, but only the oleic. The precipitated bi-salts are to be washed and dissolved in hot alcohol, of specific gravity 0·820, of which they require about 24 times their weight. During the cooling of the solution, the bi-stearate falls down, while the greater part of the bi-margarate, and the remainder of the oleate, remain dissolved. By once more dissolving in alcohol, and crystallizing, the bi-stearate will be obtained alone; as may be proved by decomposing a little of it in water at a boiling heat, with muriatic acid, letting it cool, washing the stearic acid obtained, and exposing it to heat, when, if pure, it will not fuse in water under the 158th degree of Fahrenheit's scale. If it melts at a lower heat, it contains more or less margaric acid. The purified bi-stearate being decomposed by boiling in water along with any acid, as the muriatic, the disengaged stearic acid is to be washed by melting in water, then cooled and dried.

Stearic acid, prepared by the above process, contains combined water, from which it cannot be freed. It is insipid and inodorous. After being melted by heat, it solidifies at the temperature of 158° Fahrenheit, and affects the form of white brilliant needles grouped together. It is insoluble in water, but dissolves in all proportions in boiling anhydrous alcohol, and on cooling to 122°, crystallizes therefrom, in pearly plates; but if the concentrated solution be quickly cooled to 112°, it forms a crystalline mass. A dilute solution affords the acid crystallized in large white brilliant scales. It dissolves in its own weight of boiling ether of 0·727, and crystallizes on cooling in beautiful scales, of changing colors. It distils over *in vacuo* without alteration; but if the retort contains a little atmospheric air, a small portion of the acid is decomposed during the distillation; while the greater part passes over unchanged, but slightly tinged brown, and mixed with traces of empyreumatic oil. When heated in the open air, and kindled, stearic acid burns like wax. It contains 3·4 per cent. of water, from which it may be freed by combining it with oxyde of lead. When this anhydrous acid is subjected to ultimate analysis, it is found to consist of—80 of carbon, 12·5 hydrogen, and 7·5 oxygen, in 100 parts. Stearic acid displaces, at a boiling heat in water, carbonic acid from its combinations with the bases; but in operating upon an alkaline carbonate, a portion of the stearic acid is dissolved in the liquor before the carbonic acid is expelled. This decomposition is founded upon the principle, that the stearic acid transforms the salt into a bicarbonate, which is decomposed by the ebullition.

Stearic acid put into a strong watery infusion of litmus, has no action upon it in the cold; but when hot, the acid combines with the alkali of the litmus, and changes its blue color to red; so that it has sufficient energy to abstract from the concentrated tincture all the alkali required for its neutralization. If we dissolve bi-stearate of potash in weak alcohol, and pour litmus water, drop by drop, into the solution, this will become red, because the litmus will give up its alkali to a portion of the bi-stearate, and will convert it into neutral stearate. If we now add cold water, the reddened mixture will resume its blue tint, and will deposite bi-stearate of potash in small spangles. In order that the alcoholic solution of the bi-stearate may redden the litmus, the alcohol should not be very strong.

From the composition of stearate of potash, the atomic weight of the acid appears to be 106·6; hydrogen being 1; for 18 : 48 × 2 :: 100 : 533·3 = 5 atoms of acid.

From the stearate of soda, it appears to be 104; and from that of lime, 102. The stearate of lead, by Chevreul, gives 109 for the atomic weight of the acid.

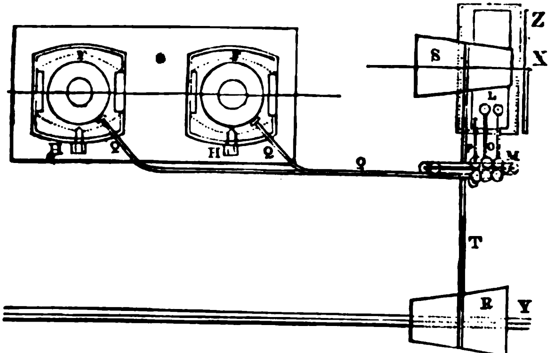
The margaric and oleic acids seem to have the same neutralizing power, and the same atomic weight.

The preceding numbers will serve to regulate the manufacture of stearic acid for the purpose of making candles. Potash and soda were first prescribed for saponifying fat, as may be seen in M. Gay Lussac's patent, under the article Candle; and were it not for the cost of these articles, they are undoubtedly preferable to all others in a chemical point of view. Of late years lime has been had recourse to, with perfect success, and has become subservient to a great improvement in candle-making. The stearine block now made by many London houses, though containing not more than 2 or 3 per cent. of wax, is hardly to be distinguished from the purified produce of the bee. The first process is to boil the fat with quicklime and water in a large tub, by means of perforated steam pipes distributed over its bottom. From the above statements we see that about 11 parts of dry lime are fully equivalent to 100 of stearine and oleine mixed: but as the lime is in the state of hydrate, 14 parts of it will be required when it is perfectly pure; in the ordinary state, however, as made from average good limestone, 16 parts may be allowed. After a vigorous ebullition of 3 or 4 hours, the combination is pretty complete. The stearate being allowed to cool to such a degree as to allow of its being handled, becomes a concrete mass, which must be dug out with a spade, and transferred into a contiguous tub, in order to be decomposed with the equivalent quantity of sulphuric acid diluted with water, and also heated with steam. Four parts of concentrated acid will be sufficient to neutralize three parts of slaked lime. The saponified fat now liberated from the lime, which is thrown down to the bottom of the tub in the state of sulphate, is skimmed off the surface of the watery menstruum into a third contiguous tub, where it is washed with water and steam.

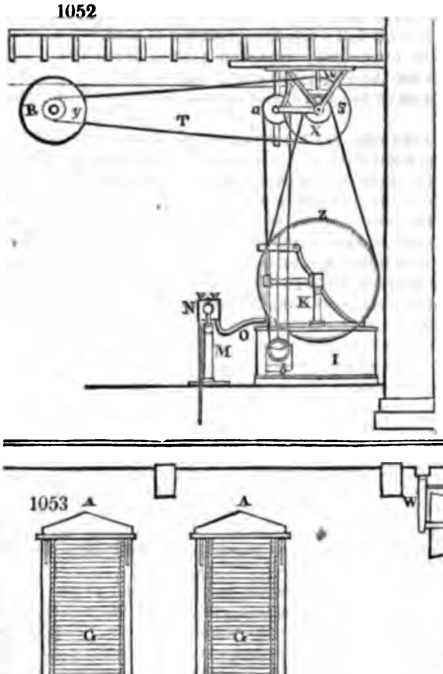
The washed mixture of stearic, margaric, and oleic acids, is next cooled in tin pans; then shaved by large knives, fixed on the face of a fly-wheel, called a tallow cutter, preparatory to its being subjected in canvass or caya bags to the action of a powerful hydraulic press. Here a large portion of the oleic acid is expelled, carrying with it a little of the margaric. The pressed cakes are now subjected to the action of water and steam once more, after which the supernatant stearic acid is run off, and cooled in moulds. The cakes are then ground by a rotatory rasping-machine to a sort of mealy powder, which is put into canvass bags, and subjected to the joint action of steam and pressure in a horizontal hydraulic press of a peculiar construction, somewhat similar to that which has been long used in London for pressing spermaceti. The cakes of stearic acid thus freed completely from the margaric and oleic acids, are subjected to a final cleansing in a tub with steam, and then melted into hemispherical masses called blocks. When these blocks are broken, they display a highly crystalline texture, which would render them unfit for making candles. This texture is therefore broken down or comminuted by fusing the stearine in a plated copper pan, along with one thousandth part of pulverized arsenious acid, after which it is ready to be cast into candles in appropriate moulds. See Candle.

STEARINE COLD PRESS. The cold hydraulic press, as mounted by Messrs. Maudslay and Field, for squeezing out the oleic acid from saponified fat, or the oleine from cocoa-nut lard, is represented in plan in *fig.* 1051; in side view of pump in *fig.* 1052; and in elevation, *fig.* 1053; where the same letters refer to like objects.

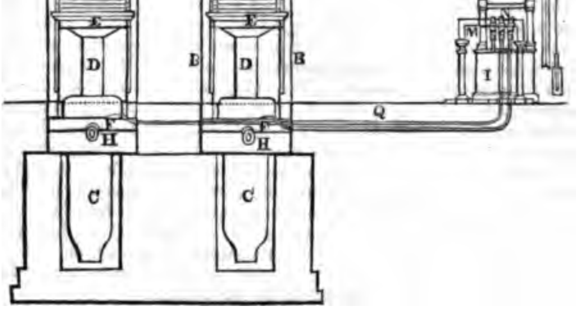
1051 *Scale 3-20ths of an inch to the foot.*



1052



1053



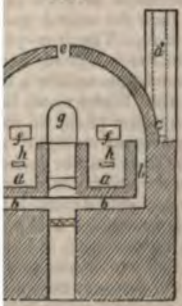
A, A, are two hydraulic presses; B the frame; C, the cylinder; D, the piston or ram; E, the follower; F, the recess in the bottom to receive the oil; G, twilled woollen bags with the material to be pressed, having a thin plate of wrought iron between each; H, apertures for the discharge of the oil; I, cistern in which the pumps are fixed; K, framing for machinery to work in; L, two pumps, large and small, to inject the water into the cylinders; M, a frame containing three double branches; N, three branches, each having two stops or plugs, by which the action of one of the pumps may be intercepted from, or communicated to, one or both of the presses; the large pump is worked at the beginning of the operation, and the small one towards the end; by these branches, one or both presses may be discharged when the operation is finished; O, two pipes from the pumps to the branches; P, pipe to return the water from the cylinders to the cisterns; Q, pipes leading from the pumps through the branches to the cylinders; R, conical drum, fixed upon the main shaft Y, driven by the steam-engine of the factory; S, a like conical drum to work the pumps; T, a narrow leather strap to communicate the motion from R to S; U, a long screw bearing a nut, which works along the whole length of the drum; V, the fork or guide for moving the strap T; W, W, two hanging bearings to carry the drum S; X, a pulley on the spindle of the drum S; Y, the main shaft; Z, fly-wheel with groove on the edge, driven by the pulley X; on the axis of S, is a double crank, which works the two pumps L. *a*, is a on the end of the long screw U; an endless cord passes twice round this pulley, ıder a pulley fixed in the weight *b*; by laying hold of both sides of this cord, and ; or lowering it, the forked guide V, and the leather strap T, are moved backwards vards, by means of the nut fixed in the guide, so as to accelerate or retard at plea- he speed of the working of the pumps; *c*, is a piece of iron, with a long slit, in a pin, attached to the fork V, travels, to keep it in the vertical position.

:ATITE (*Soapstone; Craie de Briançon*, Fr.; *Speckstein*, Germ.), is a mineral of agnesian family. It has a grayish-white or greenish-white color, often marked endritic delineations, and occurs massive, as also in various supposititious crystal- ırms; it has a dull or fatty lustre; a coarse splintery fracture, with translucent a shining streak; it writes feebly; is soft, and easily cut with a knife; but some- ough; does not adhere to the tongue; feels very greasy; infusible before the blow- specific gravity from 2·6 to 2·8. It consists of—silica, 44; magnesia, 44; alumina, ı, 7·3; manganese, 1·5; chrome, 2; with a trace of lime. It is found frequently ll contemporaneous veins that traverse serpentine in all directions, as at Portsoy, tland, in the limestone of Icolmkiln, in the serpentine of Cornwall, in Anglesey, in ', Bavaria, (at Bayruth,) Hungary, &c. It is used in the manufacture of porce- It makes the buiscuit semi-transparent, but rather brittle, and apt to crack with changes of heat. It is employed for polishing serpentine, marble, gypseous alabas- d mirror glass; as the basis of cosmetic powders; as an ingredient in anti-attrition ; it is dusted in powder upon the inside of boots, to make the feet glide easily into when rubbed upon grease-spots in silk and woollen clothes, it removes the stains ıorption; it enters into the composition of certain crayons, and is used itself for ; traces upon glass, silk, &c. The spotted steatite, cut into cameos and calcined, :s an onyx aspect. Soft steatite forms excellent stoppers for the chemical appara- :d in distilling or subliming corrosive vapors. Lamellar steatite is TALC.

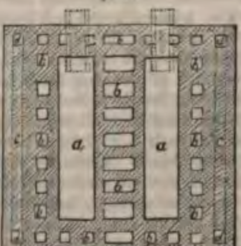
:EL (*Acier*, Fr.; *Stahl*, Germ.), as a carburet of iron, has already been considered that metal. I shall treat in this article more particularly of its manufacture and :al relations.

teel of cementation, bar or blistered steel.—With the exception of the Ulverstone al iron, no bars are manufactured in Great Britain capable of conversion into steel ıpproaching in quality to that made from the Madras, Swedish, and Russian irons, ely imported for that purpose. The first rank is assigned to the Swedish iron :d with a circle enclosing the letter L (hence called hoop L); which fetches the high f 36*l*. 10*s*. per ton, while excellent English coke-iron may be had for one fifth of ce. The other Swedish irons are sold at a much lower rate, though said to be ıctured in the same way; and therefore the superiority of the Dannemora iron must ing to some peculiarity in the ore from which it is smelted. The steel recently in the Indian steel-works at Chelsea, from Mr. Heath's Madras iron, rivals that ıe hoop L.

1054



1055



Sheffield furnace for making bar or blistered steel, called the furnace of cementa- ; represented in *fig*. 1054, in a cross section, and in *fig*. 1055, in a ground plan. The hearth of this oblong quadrangular furnace, is divided by a grate into two parts, upon each side of which there is a chest *a*, called a *trough*, made of fire-clay, or fire-tiles. The breadth of the grate varies according to the quality of the fuel. *b*, *b*, are air-holes; *c*, *c*, flues leading to the chimney *d*, *d*. To aid the draught of the smoke and the flame, an opening *e*, is made in the middle of the flat arch of the furnace. In one of its shorter sides (ends), there are orifices *f*, *f*, through which the long bars of iron : put in and taken out; g, is the door by which the steel-maker enters, in filling tying the trough; *h*, is a proof hole, at which small samples of the steel, in the ts conversion, may be drawn out. The furnace is built under a conical hood or ·y, from thirty to fifty feet high, for aiding the draught, and carrying off the

two chests are built of fire-stone grit. They are 8, 10, or even 15 feet long, and 6 to 36 inches in width and depth; the lower and smaller they are, the more n will the quality of the steel be. A great breadth and height of trough are incompatible with equability of the cementing temperature. The sides are a few inches thick. The space between them is at least a foot wide. They should never rest directly upon the sole of the furnace, but must have their bottom freely played upon by the flame, as well as the sides and top. The degree of heat is regulated by openings in the arch, or upon the long sides of the furnace, which lead to the chimney; as also by the greater or less quantity of air admitted below the grate, as in glass-house furnaces.

The *cement* consists of ground charcoal (sometimes of soot), mixed with one tenth of ashes, and some common salt; the charcoal of hard wood being preferred. Ground coke is inadmissible, on account of the sulphur, silica, and clay, which it generally contains. Possibly the salt serves to vitrify the particles of silica in the charcoal, and thus to prevent their entering into combination with the steel. As for the ashes, it is difficult to discover their use. The best steel may be made without their presence. The bottom of the trough being covered with two inches of the powder of cementation, the bars are laid along in it, upon their narrow edge, the side bar being one inch from the trough, and the rest being from one half to three fourths of an inch apart. Above this first layer of iron bars, fully half an inch depth of the powder is spread, then a new series of bars is stratified, and so on till the trough is filled within six inches of the top. This space is partially filled with old cement powder, and is covered with refractory damp sand. Sometimes the trough is filled to the surface with the old cement, and then closely covered with fire-tiles. The bars should never be allowed to touch each other, or the trough. The fire must be carefully urged from two to four days, till it acquires the temperature of 100° Wedgewood; which must be steadily maintained during the four, six, eight, or ten days requisite for the cementation; a period dependant on the size of the furnace, and which is determined by the examination of the proof pieces, taken out from time to time.

In the front or remote end of the furnace, *fig.* 1054, a door is left in the outer building, corresponding to a similar one in the end of the interior vault, through which the workman enters for charging the furnace with charcoal and iron bars, as also for taking out the steel after the conversion. Small openings are likewise made in the ends of the chests, through which the extremities of a few bars are left projecting, so that they may be pulled out and examined, through small doors opposite to them in the exterior walls. These *tap* holes, as they are called, should be placed near the centre of the end stones of the chests, that the bars may indicate the average state of the process. The joinings of the fire-stones are secured with a finely ground Stourbridge clay.

The interval between the two chests (in furnaces containing two, for many have only one) being covered with an iron platform, the workman stands on it, and sifts a layer of charcoal on the bottom of the chests evenly, about half an inch thick; he then lays a row of bars, cut to the proper length, over the charcoal, about an inch from each other; he next sifts on a second stratum of charcoal-dust, which, as it must serve for the bars above, as well as below, is made an inch thick; thus, he continues to stratify, till the chest be filled within two inches of the top; and he covers the whole with the earthy detritus found at the bottom of grindstone troughs, or any convenient fire-loam. It is obvious that the second series of bars should correspond vertically with the interstices between the first series, and so in succession. The trial-rods are left longer than the others, and their projecting ends are incrusted with fire-clay, or imbedded in sand. The iron platform being removed, and all the openings into the vault closed, the fire is lighted, and very gradually increased, to avoid every risk of cracking the grit-stone by too sudden a change of temperature; and the ignition being finally raised to about 100° Wedgewood, but not higher, for fear of melting the metal, must be maintained at a uniform pitch, till the iron have absorbed the desired quantity of carbon, and have been converted as highly as the manufacturer intends for his peculiar object. From six to eight days may be reckoned a sufficient period for the production of steel of moderate hardness, and fit for tilting into shear steel. A softer steel, for saws and springs, takes a shorter period; and a harder steel, for fabricating chisels used in cutting iron, will need longer exposure to the ignited charcoal. But, for a few purposes, such as the bits for boring cast iron, the bars are exposed to two or three successive processes of cementation, and are hence said to be twice or thrice converted into steels. The higher the heat of the furnace, the quicker is the process of conversion.

The furnace being suffered to cool, the workman enters it again, and hands out the steel bars, which being covered with blisters, from the formation and bursting of vesicles on the surface filled with gaseous carbon, is called *blistered steel*. This steel is very irregular in its interior texture, has a white color, like frosted silver, and displays crystalline angles and facettes, which are larger the further the cementation has been urged, or the greater the dose of carbon. The central particles are always smaller than those near the surface of the bar.

In such a furnace as the above, twelve tons of bar iron may be converted at a charge.

But other furnaces are constructed with one chest, which receives six or eight tons at a time; the small furnaces, however, consume more fuel in proportion than the larger.

The absorption and action of the carbonaceous matter, to the amount of about a half per cent., occasions fissures and cavities in the substance of the blistered bars, which render the steel unfit for any useful purpose in tool-making, till it be condensed and rendered uniform by the operation of *tilting*, under a powerful hammer driven by machinery. See Iron.*

The heads of the tilt-hammers for steel weigh from one and a half to two hundred pounds. Those in the neighborhood of Sheffield are much simpler than the one referred to in the note. They are worked by a small water-wheel, on whose axis is another wheel, bearing a great number of cams or wipers on its circumference, which strike the tail of the hammer in rapid succession, raise its head, and then let it fall smartly on the hot metal rod, dexterously presented on its several parts to the anvil beneath it, by the workman. The machinery is adapted to produce from 300 to 400 blows per minute; which on this plan requires an undue and wasteful velocity of the float-boards. Were an intermediate toothed wheel substituted between the water-wheel and the wiper-wheel, so that while the former made one turn, the latter might make three, a much smaller force of water would do the work. The anvils of the tilt-hammer are placed nearly on a level with the floor of the mill-house; and the workman sits in a fosse, dug on purpose, in a direction perpendicular to the line of the helve, on a board suspended from the roof of the building by a couple of iron rods. On this swinging seat, he can advance or retire with the least impulse of his feet, pushing forward the steel bar, or drawing it back with equal rapidity and convenience.

At a small distance from each tilt, stands the forge-hearth, for heating the steel. The bellows for blowing the fire are placed above-head, and are worked by a small crank fixed on the end of the axis of the wheel, the air being conveyed by a copper pipe down to the nozzle. Each workman at the tilt has two boys in attendance, to serve him with hot rods, and to take them away after they are hammered. In small rods, the bright ignition originally given at the forge soon declines to darkness; but the rapid impulsions of the tilt revive the redness again in all the points near the hammer; so that the rod, skilfully handled by the workman, progressively ignites where it advances to the strokes. Personal inspection alone can communicate an adequate idea of the precision and celerity with which a rude steel rod is stretched and fashioned into an even, smooth, and sharp-edged prism, under the operation of the tilt-hammer. The heat may be clearly referred to the prodigious friction among the particles of so cohesive a metal, when they are made to slide so rapidly over each other in every direction during the elongation and squaring of the rod.

2. *Shear steel* derives its name from the accidental circumstance of the shears for dressing woollen cloth being usually forged from it. It is made by binding into a bundle, with a slender steel rod, four parallel bars of blistered steel, previously broken into lengths of about 18 inches, including a fifth of double length, whose projecting end may serve as a handle. This fagot, as it is called, is then heated in the forge-hearth to a good welding-heat, being sprinkled over with sand to form a protecting film of iron slag, carried forthwith to the tilt, and notched down on both sides to unite all the bars together, and close up every internal flaw or fissure. The mass being again heated, and the binding rings knocked off it, is drawn out into a uniform rod of the size required. Manufacturers of cutlery are in the habit of purchasing the blistered bars at the conversion furnaces, and sending them to tilt-mills to have them drawn out to the proper size, which is done at regular prices to the trade; from 5 to 8 per cent. discount being allowed on the rude bars for waste in the tilting. The metal is rendered so compact by the welding and hammering, as to become susceptible of a much finer polish than blistered steel can take; while the uniformity of its body, tenacity, and malleability are at the same time much increased; by which properties it becomes well adapted for making table knives and powerful springs, such as those of gun-locks. The steel is also softened down by this process, probably from the expulsion of a portion of its carbon during the welding and subsequent heats; and if these be frequently or awkwardly applied, it may pass back into common iron.

3. *Cast steel* is made by melting, in the best fire-clay crucibles, blistered steel, broken down into small pieces of convenient size for packing; and as some carbon is always dissipated in the fusion, a somewhat highly converted steel is used for this purpose. The furnace is a square prismatic cavity, lined with fire-bricks, 12 inches in each side, and 24 deep, with a flue immediately under the cover, 3½ inches by 6, for conducting the smoke into an adjoining chimney of considerable height. In some establishments a dozen such furnaces are constructed in one or two ranges, their tops being on a level with the floor of the laboratory, as in brass-foundries, for enabling the workmen more

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* For minute details of the parts, see the excellent article Tilting-hammer, in *Rees's Cyclopædia*.

conveniently to inspect, and lift out, the crucibles with tongs. The ash-pits terminate in a subterraneous passage, which supplies the grate with a current of cool air, and serves for emptying out the ashes. The crucible stands, of course, on a sole-piece of baked fire-clay; and its mouth is closed with a well-fitted lid. Sometimes a little bottle-glass, or blast-furnace slag, is put into the crucible, above the steel pieces, to form a vitreous coating, that may thoroughly exclude the air from oxydizing the metal. The fuel employed in the cast-steel furnace is a dense coke, brilliant and sonorous, broken into pieces about the size of an egg, one good charge of which is sufficient. The tongs are furnished at the fire end with a pair of concave jaws, for embracing the curvature of the crucible, and lifting it out whenever the fusion is complete. The lid is then removed, the slag or scoriæ cleared away, and the liquid metal poured into cast-iron octagonal or rectangular moulds, during which it throws out brilliant scintillations.

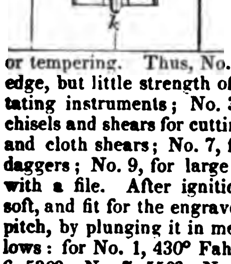
Cast-steel works much harder under the hammer than shear steel, and will not, in its usual state, bear much more than a cherry-red heat without becoming brittle; nor can it bear the fatigue incident to the welding operation. It may, however, be firmly welded to iron, through the intervention of a thin film of vitreous boracic acid, at a moderate degree of ignition. Cast steel, indeed, made from a less carbureted bar steel, would be susceptible of welding and hammering at a higher temperature; but it would require a very high heat for its preparation in the crucible.

Iron may be very elegantly plated with cast steel, by pouring the liquid metal from the crucible into a mould containing a bar of iron polished on one face. In this circumstance the adhesion is so perfect as to admit of the two metals being rolled out together; and in this way the chisels of planes and other tools may be made, at a moderate rate and of excellent quality, the cutting-edge being formed in the steel side. Such instruments combine the toughness of iron with the hardness of steel.

For correcting the too high carbonization of steel, or equalizing the too highly converted exterior of a bar with the softer steel of the interior, the metal requires merely to be imbedded, at a cementing heat, in oxyde of iron or manganese; the oxygen of which soon abstracts the injurious excess of carbon, so that the outer layers may be even converted into soft iron, while the axis continues steely; because the decarbonizing advances far more rapidly than the carbonizing.

Fig. 1056 represents the mould for making crucibles for the cast-steel works. M M, is a solid block of wood, to support the two-handled outside mould N, N. This being rammed full of the proper clay dough or compost (see CRUCIBLE), the inner mould is to be then pressed vertically into it, till it reaches the bottom P, being directed and facilitated in its descent by the point *k*. A cord passes through O, by which the inner mould is suspended over a pulley, and guided in its motions.

1056



When a plate of polished steel is exposed to a progressive heat, it takes the following colors in succession: 1, a faint yellow; 2, a pale straw-color; 3, a full yellow; 4, a brown yellow; 5, a brown with purple spots; 6, a purple; 7, a bright blue; 8, a full blue; 9, a dark blue, verging on black; after which the approach to ignition supersedes all these colors. If the steel plate has been previously hardened by being dipped in cold water or mercury when red-hot, then those successive shades indicate or correspond to successive degrees of softening or tempering. Thus, No. 1 suits the hard temper of a lancet, which requires the finest edge, but little strength of metal; No. 2 a little softer, for razors and surgeons' amputating instruments; No. 3, somewhat more toughness, for penknives; No. 4, for cold chisels and shears for cutting iron; No. 5, for axes and plane-irons; No. 6, for table knives and cloth shears; No. 7, for swords and watch-springs; No. 8, for small fine saws and daggers; No. 9, for large saws, whose teeth need to be set with pliers, and sharpened with a file. After ignition, if the steel be very slowly cooled, it becomes exceedingly soft, and fit for the engraver's purposes. Hardened steel may be tempered to the desired pitch, by plunging it in metallic baths heated to the proper thermometric degree, as follows: for No. 1, 430° Fahr.; No. 2, 450°; No. 3, 470°; No. 4, 490°; No. 5, 510°; No. 6, 530°; No. 7, 550°; No. 8, 560°; No. 9, 600°.

Small steel tools are most frequently tempered, after hardening, by covering their surface with a thin coat of tallow, and heating them in the flame of a candle till the tallow diffuses a faint smoke, and then thrusting them into the cold tallow. Hinman long ago defined steel to be any kind of iron which, when heated to redness, and then plunged in cold water, becomes harder. But several kinds of cast iron are susceptible of such hardening. Every malleable and flexible iron, however, which may be hardened in that way is a steel. Moreover, steel may be distinguished from pure iron by its giving a dark-gray spot when a drop of dilute nitric acid is let fall on its surface, while iron affords a green one. Exposed to the air, steel rusts less rapidly than iron; and the more highly carbureted, the more slowly does it rust, and the blacker is the spot left by an acid.

After hardening, steel seems to be quite a different body; even its granular texture becomes coarser or finer, according to the degree of heat to which it was raised; it grows so hard as to scratch glass, and resist the keenest file, while it turns exceedingly brittle. When a slowly cooled steel rod is forged and filed, it becomes capable of affording agreeable and harmonious sounds by its vibrations; but hard-tempered steel affords only dull deafened tones, like those emitted by a cracked instrument.

The good quality of steel is shown by its being homogeneous; being easily worked at the forge; by its hardening and tempering well; by its resisting or overcoming forces; and by its elasticity. To ascertain the first point, the surface should be ground and polished on the wheel; when its lustre and texture will appear. The second test requires a skilful workman to give it a heat suitable to its nature and state of conversion. The size and color of the grain are best shown by taking a bar forged into a razor form; hardening and tempering it; and then breaking off the thin edge in successive bits with a hammer and anvil. If it had been fully ignited only at the end, then, after the hardening, it will display, on fracture, a succession in the aspect of its grains from that extremity to the other; as they are whiter and larger at the former than the latter. The other qualities become manifest on filing the steel; using it as a chisel for cutting iron; or bending it under a heavy weight.

Much interest was excited a few years back by the experiments of Messrs. Stodart and Faraday on the alloys of steel with silver, platinum, rhodium, and iridium. Steel refuses to take up in fusion more than one five-hundredth part of silver; but with this minute quantity of alloy, it is said to bear a harder temper, without losing its tenacity. When pure iron is substituted for steel, the alloys so formed are much less subject to oxydation in damp air than before. With three *per cent.* of iridium and osmium, an alloy was obtained which had the property of tempering like steel, and of remaining clean and bright, in circumstances when simple iron became covered with rust. "Upon the whole," says the editor of the Quarterly Journal of Science, giving a report of these experiments in his 14th volume, p. 378, "though we consider these researches upon the alloys of steel as very interesting, we are not sanguine as to their important influence upon the improvement of the manufacture of cutlery, and suspect that a bar of the best ordinary steel, selected with precaution, and most carefully forged, wrought, and tempered, *under the immediate inspection of the master*, would afford cutting instruments as perfect and excellent as those composed of wootz, or of the alloys."

Case-hardening of iron, is a process for converting a thin film of the outer surface into steel, while the interior remains as before. Fine keys are generally finished in this way. See CASE-HARDENING.

So great is the affinity of iron for carbon, that, in certain circumstances, it will absorb it from carbureted hydrogen, or coal-gas, and thus become converted into steel. On this principle, Mr. Mackintosh of Glasgow obtained a patent for making steel. His furnace consists of one cylinder of bricks built concentrically within another. The bars of iron are suspended in the innermost, from the top; a stream of purified coal-gas circulates freely round them, entering below and escaping slowly above, while the bars are maintained in a state of bright ignition by a fire burning in the annular space between the cylinders. The steel so produced is of excellent quality; but the process does not seem to be so economical as the ordinary cementation with charcoal powder.

Damasking of steel, is the art of giving to sabre blades a variety of figures in the style of watering. See DAMASCUS BLADES.

Several explanations have been offered of the change in the constitution of steel, which accompanies the tempering operation; but none of them seems quite satisfactory. It seems to be probable that the ultimate molecules are thrown by the sudden cooling into a constrained state, so that their poles are not allowed to take the position of strongest attraction and greatest proximity; and hence the mass becomes hard, brittle, and somewhat less dense. An analogous condition may be justly imputed to hastily cooled glass, which, like hardened steel, requires to be annealed by a subsequent nicely graduated heat, under the influence of which the particles assume the position of repose, and constitute a denser, softer, and more tenacious body. The more sudden the cooling of ignited steel, the more unnatural and constrained will be the distribution of its particles, and also the more refractory, an effect produced by plunging it into cold mercury. This excess of hardness is removed in any required degree by judicious annealing or tempering. The state of the carbon present in the steel may also be modified by the rate of refrigeration, as Mr. Karsten and M. Bréant conceive happens with cast iron and the damask metal. If the uniform distribution and combination of the carbon through the mass, determine the peculiarity of white cast iron, which is a hard and brittle substance, and if its transition to the dark-gray and softer cast metal be effected by a partial formation of plumbago during slow cooling, why may not something similar be supposed to occur with steel, an analogous compound?

Mr. Oldham, printing engineer of the Bank of England, who has had great experience in the treatment of steel for dies and mills, says that, for hardening it, the fire should never be heated above the redness of sealing-wax, and kept at that pitch for a sufficient time. On taking it out, he hardens it by plunging it, not in water, but in olive oil, or rather naptha, previously heated to 200° F. It is kept immersed only till the ebullition ceases, then instantly transferred into cold spring water, and kept there till quite cold. By this treatment the tools come out perfectly clean, and as hard as it is possible to make cast-steel, while they are perfectly free from cracks, flaws, or twist. Large tools are readily brought down in temper by being suspended in the red-hot muffle till they show a straw color; but for small tools, he prefers plunging them in the oil heated to 400 degrees; and leaves them in till they become cold.

Mr. Oldham softens his steel dies by exposing them to ignition for the requisite time, imbedded in a mixture of chalk and charcoal.

"The common mode of softening steel," says Mr. Baynes, "is to put it into an iron case, surrounded with a paste made of lime, cow's gall, and a little nitre and water; then to expose the case to a slow fire, which is gradually increased to a considerable heat, and afterwards allowed to go out, when the steel is found to be soft and ready for the engraver."*

Indian steel or wootz.—The wootz ore consists of the magnetic oxyde of iron, united with quartz, in proportions which do not seem to differ much, being generally about 42 of quartz, and 58 of magnetic oxyde. Its grains are of various size, down to a sandy texture. The natives prepare it for smelting by pounding the ore, and winnowing away the stony matrix, a task at which the Hindoo females are very dexterous. The manner in which iron ore is smelted and converted into wootz or Indian steel, by the natives at the present day, is probably the very same that was practised by them at the time of the invasion of Alexander; and it is a uniform process, from the Himalaya mountains to Cape Comorin. The furnace or bloomery in which the ore is smelted, is from four to five feet high; it is somewhat pear-shaped, being about two feet wide at bottom, and one foot at top; it is built entirely of clay, so that a couple of men can finish its erection in a few hours, and have it ready for use the next day. There is an opening in front about a foot or more in height, which is built up with clay at the commencement, and broken down at the end, of each smelting operation. The bellows are usually made of a goat's skin, which has been stripped from the animal without ripping open the part covering the belly. The apertures at the legs are tied up, and a nozzle of bamboo is fastened in the opening formed by the neck. The orifice of the tail is enlarged and distended by two slips of bamboo. These are grasped in the hand, and kept close together in making the stroke for the blast; in the returning stroke they are separated to admit the air. By working a bellows of this kind with each hand, making alternate strokes, a pretty uniform blast is produced. The bamboo nozzles of the bellows are inserted into tubes of clay, which pass into the furnace at the bottom corners of the temporary wall in front. The furnace is filled with charcoal, and a lighted coal being introduced before the nozzles, the mass in the interior is soon kindled. As soon as this is accomplished, a small portion of the ore, previously moistened with water, to prevent it from running through the charcoal, but without any flux whatever, is laid on the top of the coals, and covered with charcoal to fill up the furnace.

In this manner ore and fuel are supplied; and the bellows are urged for 3 or 4 hours, when the process is stopped; and the temporary wall in front being broken down, the bloom is removed by a pair of tongs from the bottom of the furnace. It is then beaten with a wooden mallet, to separate as much of the scoriæ as possible from it, and, while still red-hot, it is cut through the middle, but not separated, in order merely to show the quality of the interior of the mass. In this state it is sold to the blacksmiths, who make it into bar iron. The proportion of such iron made by the natives from 100 parts of ore, is about 15 parts. In converting the iron into steel, the natives cut it into pieces, to enable it to pack better in the crucible, which is formed of refractory clay, mixed with a large quantity of charred husk of rice. It is seldom charged with more than a pound of iron, which is put in with a proper weight of dried wood chopped small, and both are covered with one or two green leaves; the proportions being in general 10 parts of iron to 1 of wood and leaves. The mouth of the crucible is then stopped with a handful of tempered clay, rammed in very closely, to exclude the air. The wood preferred is the *Cassia auriculata*, and the leaf that of the *Asclepias gigantea*, or

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[*] History of the Cotton Manufacture, p. 275. If that strange farrago be employed by Mr. Locket of Manchester, for softening his dies and mills, it deserves consideration. Should the nitre be used in too great quantity to be all carbonated by the gall, its oxygen may serve to consume some of the carbon of the steel, and thus bring it nearer to iron. The recipe may be old, but it is a novelty to me.

the *Convolvulus laurifolius*. As soon as the clay plugs of the crucibles are dry, from 20 to 24 of them are built up in the form of an arch, in a small blast furnace; they are kept covered with charcoal, and subjected to heat urged by a blast for about two hours and a half, when the process is considered to be complete. The crucibles being now taken out of the furnace and allowed to cool, are broken, and the steel is found in the form of a cake, rounded by the bottom of the crucible. When the fusion has been perfect, the top of the cake is covered wirh striæ, radiating from the centre, and is free from holes and rough projections; but if the fusion has been imperfect, the surface of the cake has a honeycomb appearance, with projecting lumps of malleable iron. On an average, four out of five cakes are more or less defective. These imperfections have been tried to be corrected in London by re-melting the cakes, and running them into ingots; but it is obvious, that when the cakes consist partially of malleable iron and of unreduced oxyde, simple fusion cannot convert them into good steel. When care is taken, however, to select only such cakes as are perfect, to re-melt them thoroughly, and tilt them carefully into rods, an article has been produced which possesses all the requisites of fine steel in an eminent degree. In the Supplement to the Encyclopædia Britannica, article *Cutlery*, the late Mr. Stodart, of the Strand, a very competent judge, has declared "that for the purposes of fine cutlery, it is infinitely superior to the best English cast steel."

The natives prepare the cakes for being drawn into bars by annealing them for several hours in a small charcoal furnace, actuated by bellows; the current of air being made to play upon the cakes while turned over before it; whereby a portion of the combined carbon is probably dissipated, and the steel is softened; without which operation the cakes would break in the attempt to draw them. They are drawn by a hammer of a few pounds weight.

The natives weld two pieces of cast steel, by giving to each a sloping face jagged all over with a small chisel; then applying them with some calcined borax between, and tying them together with a wire, they are brought to a full red heat, and united by a few smart blows of a hammer.

The ordinary bar iron of Sweden and England, when converted by cementation into steel, exhibits upon its surface numerous small warty points, but few or no distinct vesicular eruptions; whereas the Dannemora and the Ulverston steels present, all over the surface of the bars, well raised blisters, upwards of three eighths of an inch in diameter horizontally, but somewhat flattened at top. Iron of an inferior description, when highly converted in the cementing-chest, becomes gray on the outer edges of the fracture; while that of Dannemora acquires a silvery color and lustre on the edges, with crystalline facets within. The highly converted steel is used for tools that require to be made very hard; the slightly converted, for softer and more elastic articles, such as springs and sword blades.

STEREOTYPE PRINTING signifies printing by fixed types, or by a cast typographic plate. This plate is made as follows:—The form, composed in ordinary types, and containing one, two, three, or more pages, inversely as the size of the book, being laid flat upon a slab, with the letters looking upwards, the faces of the types are brushed over with oil, or preferably, with plumbago (black lead.) A heavy brass rectangular frame of three sides, with bevelled borders, adapted exactly to the size of the pages, is then laid down upon the chase,* to circumscribe three sides of its typography; but the fourth side, which is one end of the rectangle, is formed by placing near the types, and over the hollows of the chase, a single brass bar, having the same inwards sloping bevel as the other three sides. The complete frame resembles that of a picture, and serves to define the area and thickness of the cast, which is made by pouring the pap of Paris plaster into its interior space, up to a given line on its edges. The plaster mould, which soon sets, or becomes concrete, is lifted gently off the types, and immediately placed upright on its edge in one of the cells of a sheet-iron rack, mounted within the cast-iron oven. An able workman will mould ten sheets octavo in a day, or 160 pages. The moulds are here exposed to air heated to fully 400° F., and become perfectly dry in the course of two hours. As they are now friable and porous, they require to be delicately handled. Each mould, containing generally two pages octavo, is laid, with the impression downwards, upon a flat cast-iron plate, called the floating-plate; this plate being itself laid on the bottom of the dipping-pan, which is a cast-iron square tray, with its upright edges sloping outwards. A cast-iron lid is applied to the dipping-pan, and secured in its place by a screw. The pan having been heated to 400° in a cell of the oven, under the mould-rack, previous to receiving the hot mould, is ready to be plunged into the bath of melted alloy contained in an iron pot placed over a furnace, and it is dipped with a slight deviation from the horizontal plane, in order to facilitate the escape of the air. As there is a minute space between the back or top surface of the mould and the lid of the dipping-pan, the liquid metal, on entering into the pan through the orifices in its corners, floats up the plaster along with the iron plate on which it had been laid, thence called the floating-plate, whereby it flows freely into every line of the mould, through notches cut in its edge, and forms a layer or lamina upon its face, of a thickness corresponding to the depth of the border. Only a thin metal film is left upon the back of the mould. The dipping-pan is suspended, plunged, and removed, by means of a powerful crane, susceptible of vertical and horizontal motions in all directions. When lifted out of the bath, it is set in a water-cistern, upon bearers so placed as to allow its bottom only to touch the surface. Thus the metal first concretes below, while, by remaining fluid above, it continues to impart hydrostatic pressure during the shrinkage attendant upon refrigeration. As it thus progressively contracts in volume, more melted metal is fed into the corners of the pan by a ladle, in order to keep up the hydrostatic pressure upon the mould, and to secure a perfect impression, as well as a solid cast. Were the pan more slowly and equably cooled, by being left in the air, the thin film of metal upon the back of the inverted plaster cake would be apt to solidify first, and intercept the hydrostatic action indispensable to the purpose of filling all the lines in its face. A skilful workman makes five dips, containing two pages octavo each, in the course of an hour, or about nine and a half octavo sheets per day. The pan being taken asunder, the compound cake of mould and metal is removed, and beat upon its edges with a wooden mallet, to detach the superfluous metal. The stereotype plate is then handed over to the picker, who planes its edges truly square, turns its back flat upon a lathe to a determinate thickness, and carefully removes the little imperfections occasioned by dirt or air left among the letters when the mould was cast. Should any of them be damaged in the course of the operation, they must be cut out, and replaced by soldering in separate types of the same size and form.

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* Chase (*chassis*, frame, Fr.), quoin, (*coin*, wedge, Fr.), are terms which show that the art of printing came directly from France to England.

STILL (*Alambic*, Fr.; *Blase*, Germ.), is a chemical apparatus, for vaporizing liquids by heat in one part, called the *cucurbit*, and condensing the vapors into liquids in another part, called the *refrigeratory*; the general purpose of both combined being to separate the more volatile fluid particles from the less volatile. In its simplest form, it consists of a retort and a receiver, or of a pear-shaped matrass and a capital, furnished with a slanting tube for conducting away the condensed vapors in drops; whence the term *still*, from the Latin verb *stillare*, to drop. Its chief employment in this country being to eliminate alcohol, of greater or less strength, from fermented wash, I shall devote this article to a description of the stills best adapted to the manufacture of British spirits, referring to chemical authors* for those fitted for peculiar objects.

In respect of rapidity and extent of work, stills had attained to an extraordinary pitch of perfection in Scotland about thirty years ago, when legislative wisdom thought fit to levy the spirits duty, per annum, from each distiller, according to the capacity of his still. It having been shown, in a report presented to the House of Commons in 1799, that an 80-gallon still could be worked off in eight minutes, this fact was made the basis of a new fiscal law, on the supposition that the maximum of velocity had been reached. But, instigated by the hopes of enormous gains at the expense of the revenue, the distillers soon contrived to do the same thing in three minutes, by means of broad-bottomed shallow stills, with stirring-chains, and lofty capitals. In the year 1815, that preposterous law, which encouraged fraud and deteriorated the manufacture, was repealed. The whiskey duties having been since levied, independently of the capacity of the still, upon the quantity produced, such rapid operations have been abandoned, and processes of economy in fuel, and purity in product, have been sought after.

One of the greatest improvements in modern distilleries, is completing the analysis of crude spirit at one operation. Chemists had been long familiar with the contrivance of Woulfe, for impregnating with gaseous matter, water contained in a range of bottles; but they had not thought of applying that plan to distillation, when Edouard Adam, an illiterate workman of Montpellier, after hearing accidentally a chemical lecture upon that apparatus, bethought himself of converting it into a still. He caused the boiling-hot vapors to chase the spirits successively out of one bottle into another, so as to obtain in the successive vessels alcohol of any desired strength and purity, "*at one and the same heat.*" He obtained a patent for this invention in 1801, and was soon afterwards enabled, by his success on the small scale, to set up in his native city a magnificent distillery, which excited the admiration of all the practical chemists of that day. In November, 1805, he obtained a certificate of certain improvements for extracting from wine, at one process, the whole of its alcohol. Adam was so overjoyed, after making his first experiments, that he ran about the streets of Montpellier, telling everybody of the surprising results of his invention. Several competitors soon entered the lists with him, especially Solimani, professor of chemistry in that city, and Isaac

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* The treatises of Le Normand and Dubrunfaut may also be consulted. The French stills are in general so much complicated with a great many small pipes and passages, as to be unfit for distilling the glutinous wash of grains.

Berard, distiller in the department of Gard; who, having contrived other forms of continuous stills, divided the profits with the first inventor.

The principles of spirituous distillation may be stated as follows:—The boiling point of alcohol varies with its density or strength, in conformity with the numbers in the following table:—

Specific gravity.	Boiling point, by Fahrenheit's scale.	Specific gravity.	Boiling point, by Fahrenheit's scale.
0·7939	168·5°	0·8875	181·0°
0·8034	168·0	0·8631	183·0
0·8118	168·5	0·8765	187·0
0·8194	169·0	0·8892	190·0
0·8265	172·5	0·9013	194·0
0·8332	173·5	0·9126	197·0
0·8397	175·0	0·9234	199·0
0·8458	177·0	0·9335	201·0
0·8518	179·0		

See also the table under ALCOHOL, page 22.

Hence, the lower the temperature of the spirituous vapor which enters the refrigeratory apparatus, the stronger and purer will the condensed spirit be; because the offensive oils, which are present in the wash or wine, are less volatile than alcohol, and are brought over chiefly with the aqueous vapor. A perfect still should, therefore, consist of three distinct members; first, the cucurbit, or kettle; second, the rectifier, for intercepting more or less of the watery and oily particles; and third, the refrigerator, or condenser of the alcoholic vapors.

These principles are illustrated in the construction of the still represented in *figs.* 1057, 1058, 1059, 1060, 1061; in which the resources of the most refined French stills are combined with a simplicity and solidity suited to the grain distilleries of the United Kingdom. Three principal objects are obtained by the arrangement here shown; first, the extraction from fermented wort or wine, at one operation, of a spirit of any desired cleanness and strength; second, great economy of time, labor, and fuel; third, freedom from all danger of blowing up or boiling over, by mismanaged firing. When a combination of water, alcohol, and essential oil, in the state of vapor, is passed upwards through a series of winding passages, maintained at a determinate degree of heat, between 170° and 180°, the alcohol alone, in any notable proportion, will retain the elastic form, and will proceed onwards into the refrigeratory tube, in which the said passages terminate; while the water and the oil will be in a great measure condensed, arrested, and thrown back into the body of the still, to be discharged with the effete residuum.

The system of passages or channels, represented in *fig.* 1058, is so contrived as to bring the mingled vapors which rise from the alembic *a*, into ample and intimate contact with metallic surfaces, maintained, in a water-bath, at a temperature self-regulated by a heat-governor. See THERMOSTAT.

The neck of the alembic tapers upwards, as shown at *b*, *fig.* 1057; and at *c*, *fig.* 1058, it enters the bottom, or ingress vestibule, of the rectifier *c*, *f*. *f* is its top or egress vestibule, which communicates with the bottom one by parallel cases or rectangular channels *d*, *d*, *d*, of which the width is small, compared with the length and height. These cases are open at top and bottom, where they are soldered or riveted into a general frame within the cavity, enclosed by the two covers *f*, *c*, which are secured round their edges *e*, *e*, *e*, *e*, with bolts and packing. Each case is occupied with a numerous series of shelves or trays, placed at small distances over each other, in a horizontal or slightly inclined position, of which a side view is given in *fig.* 1059, and cross sections at *d*, *d*, *d*, *fig.* 1058. Each shelf is turned up a little at the two edges, and at one end, but sloped down at the other end, that the liquor admitted at the top may be made to flow slowly backwards and forwards in its descent through the system of shelves or trays, as indicated by the darts and spouts in *fig.* 1059. The shelves of each case are framed together by two or more vertical metallic rods, which pass down through them, and are fixed to each shelf by solder, or by screw-nuts. By this means, if the cover *f*, be removed, the sets of shelves may be readily lifted out of the cases and cleaned; for which reason they are called *moveable*.

The intervals i, i, i, *fig.* 1058, between the cases, are left for the free circulation of the water contained in the bath-vessel *g*, *g*; these intervals being considerably narrower than the cases.

Fig. 1060 represents in plan the surface of the rectifying cistern, shown in two different sections in *figs.* 1058 and 1059. *h*, *k*, *figs.* 1058 and 1060, is the heat-governor, shaped somewhat like a pair of tongs. Each leg is a compound bar, consisting of a flat bar or ruler of steel, and one of brass alloy, riveted facewise together, having their edges up and down. The links, at *k*, are joined to the free ends of these compound bars, which, receding by increase and approaching by decrease of temperature, act by a lever on the stopcock *l*, fixed to the pipe of a cold-water back, and are so adjusted by a screw-nut, that whenever the water in the bath vessel *g*, *g*, rises above the desired temperature, cold water will be admitted, through the stopcock *l*, and pipe *n*, into the bottom of the cistern, and will displace the over-heated water by the overflow-pipe *m*. Thus a perfect equilibrium of caloric may be maintained, and alcoholic vapor of correspondent uniformity transmitted to the refrigeratory.

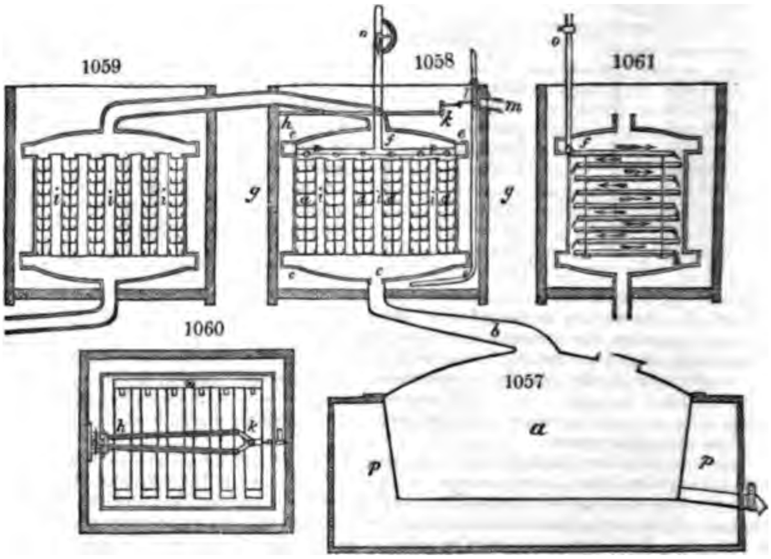


Fig. 1061 is the cold condenser, of similar construction to the rectifier, *fig.* 1058; only the water cells should be here larger in proportion to the vapor channels *d*, *d*. This refrigeratory system will be found very powerful, and it presents the great advantage of permitting its interior to be readily inspected and cleansed. It is best made of laminated tin, hardened with a little copper alloy.

The mode of working the preceding apparatus will be understood by the following instructions. Into the alembic, *a*, let as much fermented liquor be admitted as will protect its bottom from being injured by the fire, reserving the main body in the charging-back. Whenever the ebullition in the alembic has raised the temperature of the water-bath *g*, *g*, to the desired pitch, whether that be 170°, 175°, or 180°, the thermostatic instrument is to be adjusted by its screw-nut, and then the communication with the charging-back is to be opened by moving the index of the stopcock *o*, over a proper portion of its quadrantal arch. The wash will now descend in a slender equable stream, through the pipe *o*, *f*, thence spread into the horizontal tube *p*, *p*, and issue from the orifices of distribution, as seen in the figure, into the respective flat trays or spouts. The manner of its progress is seen for one set of trays, in *fig.* 1059. The direction of the stream in each shelf is evidently the reverse of that in the shelf above and below it; the turned-up end of one shelf corresponding to the discharge slope of its neighbor.

By diffusing the cool wash or wine in a thin film over such an ample range of surfaces, the constant tendency of the bath to exceed the proper limit of temperature is counteracted to the utmost, without waste of time or fuel; for the wash itself, *in transitu*, becomes boiling-hot, and experiences a powerful steam distillation. By this arrangement a very moderate influx of cold water, through the thermostatic stopcock, suffices to temper the bath; such an extensive vaporization of the wash producing a far more powerful refrigerant influence than its simple heating to ebullition. It deserves to be remarked, that the maximum distillatory effect, or the bringing over the greatest quantity of pure spirits in the least time, and with the least labor and fuel, is here accomplished without the least steam pressure in the alembic; for the passages are all pervious to the vapor; whereas, in almost every wash-still heretofore contrived for similar purposes, the spirituous vapors must force their way through successive layers of liquid, the total pressure produced by which causes undue elevation of temperature, and obstruction to the process. Whatever supplementary refrigeration of the vapors in their passage through the bath may be deemed proper, will be administered by the thermostatic regulator.

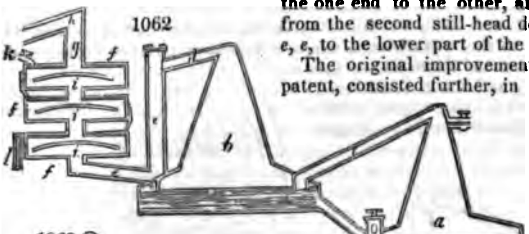
Towards the end of the process, after all the wash has entered the alembic, it may be sometimes desirable, for the sake of despatch, to modify the thermostat, by its adjusting-screw, so that the bath may take a higher temperature, and allow the residuary feints to run rapidly over, into a separate cistern. This weak fluid may be pumped back into the alembic, as the preliminary charge of a fresh operation.

The above plan of a water-bath regulated by the thermostat, may be used simply as a rectifying cistern, without transmitting the spirit or wash down through it. The series of shelves will cause the vapors from the still to impinge against a most extensive system of metallic surfaces, maintained at a steady temperature, whereby their watery and crude constituents will be condensed and thrown back, while their fine alcoholic particles will proceed forwards to the refrigeratory. Any ordinary still may be readily converted into this self-rectifying form, by merely interposing the cistern, *fig.* 1058, between the alembic and the worm-tub. The leading novelty of the present invention is the *moveable* system of shelves or trays, enclosed in metallic cases, separated by water, combined with the thermostatic regulator. By this combination, any quality of spirits may be procured at one step from wash or wine, by an apparatus, simple, strong, and easily kept in order.

The empyreumatic taint which spirits are apt to contract from the action of the naked fire on the bottom of the still, may be entirely prevented by the use of a bath of potash ley, *p*, *p*, *fig.* 1057; for thus a safe and effectual range of temperature, of 300° F., may be conveniently obtained. The still may also be used without the bath vessel.

Mr. D. T. Shears, of Southwark, obtained a patent in March, 1830, for certain improvements and additions to stills, which are ingenious. They are founded upon a previous patent, granted to Joseph Corty, in 1818; a section of whose contrivance is shown in *fig.* 1062, consisting of a first still *a*, a second still *b*, a connecting tube *c*, from the one end to the other, and the tube *d*, which leads from the second still-head down through the bent tube *e*, *e*, to the lower part of the condensing apparatus.

1062



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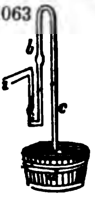
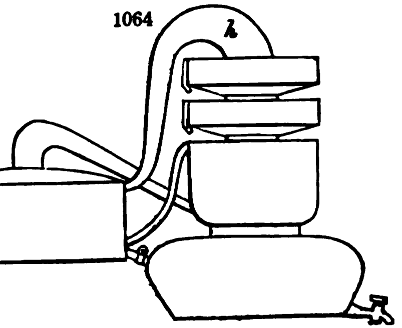


1064



The original improvements described under Corty's patent, consisted further, in placing boxes *f*, *f*, *f*, of the condensing apparatus in horizontal positions, and at a distance from each other, in order that the vapor might ascend through them, for the purpose of discharging the spirit by the top tube *g*, and pipe *h*, into the worm, in a highly rectified or concentrated state. In each of the boxes *f*, there is a convex plate or inverted dish *i*, *i*, *i*, and the vapor in rising from the tube *e*, strikes against the concave or under part of the first dish, and then escapes round its edges, and over its convex surface, to the under part of the second dish, and so on to the top, the condensed part of the vapor flowing down again into the still, and the spirit passing off by the pipe *h*, at top; and as the process of condensation will be assisted by cooling the vapor as it rises, cold water is made to flow over the tops of the boxes *f*, from a cock *k*, and through small channels or tubes on the sides of the boxes, and is ultimately discharged by the pipe *l*, at bottom.

Fig. 1063 represents a peculiarly shaped tube *a*, through which the spirit is described as passing after leaving the end of the worm at *b*, which tube is open to the atmospheric air at *x*; *c*, is the passage through which the carbonic acid gas is described as escaping into the vessel of water *d*.

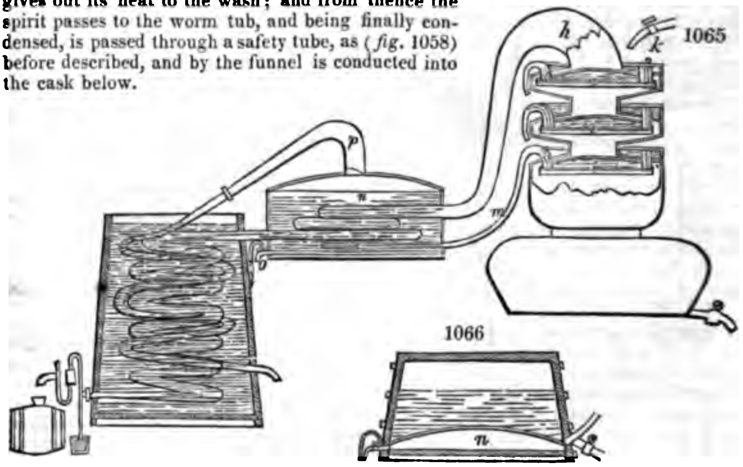
Now the improvements claimed under the present patent, are exhibited in *figs*. 1064, 1065, and 1066. *Fig*. 1064 represents the external appearance of a still, the head of which is made very capacious, to guard against over-boiling by any mismanagement of the fire; *fig*. 1065 is the same, partly in section. On the top of the still-head is formed the first-described rectifying apparatus, or series of condensing boxes. The vapor from the body of the still filling the head, meets with the first check from the dish or lower vessel *i*, and after passing under its edges, ascends and strikes against the lower part of the second dish or vessel *i*, and so on, till it ultimately leaves the still-head by the pipe at top.

This part of the apparatus is slightly altered from the former, by the substitution of hollow convex vessels, instead of the inverted dishes before described, which vessels have rims descending from their under surfaces, for the purpose of retaining the vapor. The cold water, which, as above described, flowed over the tops of the boxes *f*, for the purpose of cooling them, now flows also through the hollow convex vessels *i*, within the boxes, and by that means greatly assists the refrigerating process, by which the aqueous parts of the vapor are more readily condensed, and made to fall down and flow back again into the body of the still, while the spirituous parts pass off at top to the worm, in a very high state of rectification.

After the water employed for the refrigeration has passed over all the boxes, and through all the vessels, it is carried off by the pipe *m*, through the vessel *n*, called the wash-heater; that is, the vessel in which the wash is placed previous to introducing it into the still. The pipe *m*, is coiled round in the lower part of the vessel *n*, in order that the heated water may communicate its caloric to the wash, instead of losing the heat by allowing the water to flow away. After the heated water has made several turns round the wash heater, it passes out at the curved pipe *o*, which is bent up, in order to keep the coils of the pipe within always full of water.

Instead of the coiled pipe *n*, last described, the patentee proposes sometimes to pass the hot water into a chamber in a tub or wooden vessel, as at *n*, in *fig*. 1061, in which the wash to be heated occupies the upper part of the vessel, and is separated from the lower part by a thin metallic partition.

The swan-neck *h*, *figs*. 1064 and 1065, which leads from the head of the still, conducts the spirit from the still through the wash-heater, where it becomes partially cooled, and gives out its heat to the wash; and from thence the spirit passes to the worm tub, and being finally condensed, is passed through a safety tube, as (*fig*. 1058) before described, and by the funnel is conducted into the cask below.



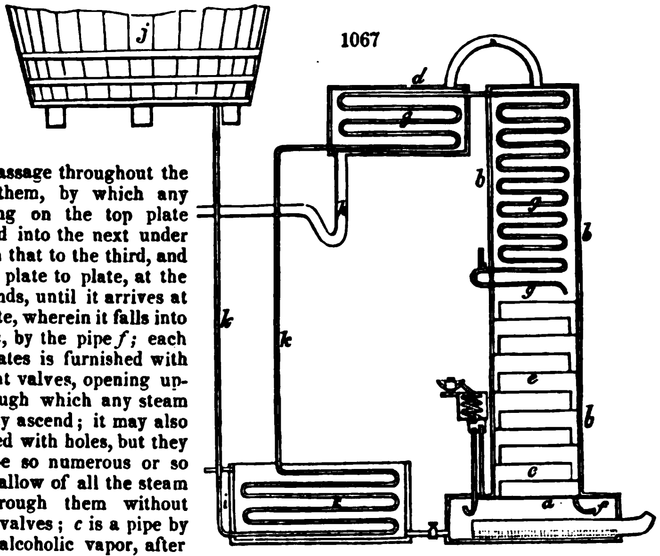
1065

1066

Should any spirit rise in the wash-heater during the above operation, it will be carried down to the worm by the neck *p*, and coiled pipe, and discharged at its lower end; or it may be passed into the still-head, as shown in *fig*. 1062.

A patent was obtained by Mr. Æneas Coffey, in August, 1830, for a still, which has been since mounted in several distilleries. It is economical in fuel, labor, and time, but is said not to produce a clean spirit, without peculiar attention.

The apparatus is represented in *fig*. 1067. *a*, *b*, *c*, *d*, is a sectional view of that part of the still wherein the wash is deprived of its alcohol, and the vapors analyzed. It is described as consisting of a chamber or vessel *a*, with the vertical chamber *b*, *c*, placed above it; the lower half of this chamber is divided into compartments by horizontal plates *e, e, e,* of thin copper or other metal; each of these plates is turned down at one side, until it nearly touches the plate next underneath it, as shown in the figure; thus leaving a passage throughout the whole of them, by which any liquid falling on the top plate may descend into the next under it, and from that to the third, and so on, from plate to plate, at the alternate ends, until it arrives at the last plate, wherein it falls into the vessel *a*, by the pipe *f;* each of these plates is furnished with several light valves, opening upwards, through which any steam or vapor may ascend; it may also be perforated with holes, but they must not be so numerous or so large as to allow of all the steam passing through them without raising the valves; *c* is a pipe by which the alcoholic vapor, after it has been analyzed, and has acquired the proper strength, is conducted into the vessel *d*, which is made perfectly close; the vapor will here be condensed on the surface of the pipe *g, g, g;* from this chamber it will descend in a liquid state into the pipe *h*, whence it may be conducted to a worm or refrigerator, to be cooled in the ordinary way; *i* is a vessel through which the spent wash flows, after being operated upon in the distilling apparatus, and is discharged in a state of ebullition; *j* is a vessel or chamber containing the wash to be distilled. A force pump may be substituted, to force the wash through the pipes *k*, and distilling apparatus, with the velocity required.



1067

The patentee states that it is requisite the wash should be passed through the pipe *k* with sufficient velocity and force, so as to prevent the deposition of sediment in the pipe; the wash, in its passage through the pipe *k*, will gradually become increased in temperature as it passes through the spent wash in the chamber, and the close vessel *d*, until it is discharged nearly at the boiling point on the upper plate in the chamber, where it comes in contact with the vapors arising from the vessel *a*.

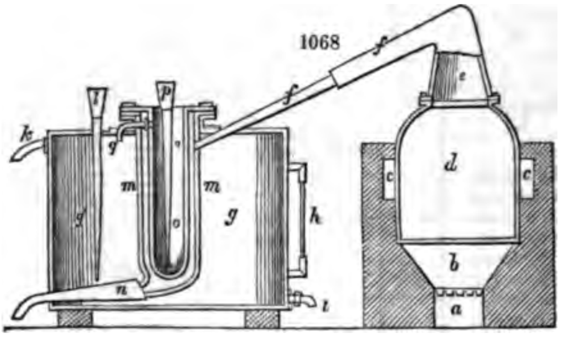
It is to be observed that the wort does not reach the boiling point while in the pipe *k, k;* to ascertain which, a thermometer is placed on the pipe, and by increasing or diminishing the quantity of wash, its temperature may be regulated. The wash, after being discharged from the pipe *k*, descends from plate to plate as before mentioned, at which time a supply of steam from a boiler, or generator, is admitted into the apparatus, through the pipe.

The lower part of this pipe in the vessel *a* is pierced with a number of small holes, so as to spread the steam over the vessel; it then rises upwards, passing through the plate by the small holes and valves, and through the stratum or sheet of wash flowing over them; the wash, as it descends, gives out a portion of its alcohol to the steam, as it passes over every plate, until it is entirely deprived of its spirit, which it will generally do by the time it arrives at the 7th or 8th plate; but it is better to employ a greater number, to guard against accidents or neglect.

A small steam pipe rises from the chamber *a*, with its upper end opening into the box or chamber; into this chamber the end of a worm projects from the cistern of cold water; the steam rising up the pipe is nearly all condensed in the worm, and flows back into the chamber *a*, by the pipe. The small portion of the steam uncondensed is allowed to escape at the upper end of the worm, and the flame of a small lamp or taper is to be constantly kept over the orifice; when, should the least quantity of alcohol descend with the wash into the chamber *a*, it will rise with the steam through the pipe and worm, and immediately take fire from the flame of the lamp or taper, thereby warning the attendant to increase the supply of steam or diminish the quantity of wash, as may seem necessary.

I shall conclude this article with a description of the cheap still which is commonly employed by the chemists in Berlin for rectifying alcohol. *a* is the ash-pit; *b*, the fire-place; *c*, *c*, the flues, which go spirally round the sides of the cucurbit *d*; *e*, the capital, made of block tin, and furnished with a brass edge, which fits tight to a corresponding edge on the mouth of *d*; *f*, *f*, the slanting pipes of the capital; *g*, the oval refrigeratory, made of copper; *h*, the water-gauge glass tube; *i*, a stop-cock for emptying the vessel; *k*, ditto for drawing off the hot water from the surface; *l*, tube for the supply of cold water. A double cylinder of tin is placed in the refrigeratory, of which the outer one, *m*, *m*, stands upon three feet, and is furnished with a discharge pipe *n*. The inner one, *o*, *o*, which is open above, receives cold water through the pipe *p*, and lets the warm water flow off through the short tube *q* into the refrigeratory. In the narrow space between the two cylinders, the vapors proceeding from the capital are condensed, and pass off in the liquid state through *n*. The refrigeratory is made oval, in order to receive two condensers alongside of each other in the line of the longer axis; though only one, and that in the middle, is represented in the figure.

1068

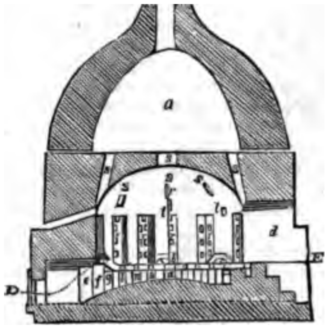


STOCKING MANUFACTURE. See Hosiery.

STONE is earthy matter, condensed into so hard a state as to yield only to the blows of a hammer, and therefore well adapted to the purposes of building. Such was the care of the ancients to provide strong and durable materials for their public edifices, that but for the desolating hands of modern barbarians, in peace and in war, most of the temples and other public monuments of Greece and of Rome would have remained perfect at the present day, uninjured by the elements during 2000 years. The contrast, in this respect, of the works of modern architects, especially in Great Britain, is very humiliating to those who boast so loudly of social advancement; for there is scarcely a public building of recent date, which will be in existence one thousand years hence. Many of the most splendid works of modern architecture are hastening to decay, in what may be justly called the very infancy of their existence, if compared with the date of those erected in ancient Italy, Greece, and Egypt. This is remarkably the case with the three bridges of London, Westminster, and Blackfriars; the foundations of which began to perish most visibly in the very lifetime of their constructors. Every stone intended for a durable edifice, ought to be tested as to its durability, by immersion in a saturated solution of sulphate of soda, and exposure during some days to the air. The crystallisation which ensues in its interior, will cause the same disintegration of its substance which frost would occasion in a series of years.

STONE, ARTIFICIAL, for statuary and other decorations of architecture, has been made for several years with singular success at Berlin, by Mr. Feilner. His materials are nearly the same with those of English pottery; and the plastic mass is fashioned either in moulds or by hand. His kilns, which are peculiar in form, and economical in fuel, deserve to be generally known. *Figs.* 1069 and 1070 represent his round kiln; *fig.* 1069 being an oblique section in the line A, B, C, of *fig.* 1070, which is a ground plan in the line D, *a*, *b*, E, of *fig.* 1069. The inner circular space *c*, covered with the elliptical arch, is filled with the figures to be baked, set upon brick supports. The hearth is a few feet above the ground; and there are steps before the door *d*, for the workmen to mount by, in charging the kiln. The fire is applied on the four sides under the hearth. The flame of each passes along the straight flues *f i*, *f i*, and *f k*. In the second annular flue *g*, *g*, as also in the third *l*, *l*, the flame of each fire is kept apart, being separated from the adjoining by the stones *h* and *m*. In the fourth flue *n*, the flames again come together, as also in *o*, and ascend by the middle opening. Besides this large orifice, there are several small holes, *p*, *p*, in the hearth over the above flues, to lead the flames from the other points into contact with the various articles. There are also channels, *q*, *q*, in the sides, enclosed by thin walls, *r*, to promote the equable distribution of the heat; and these are placed right over the first fire-flues *e*. The partitions *r*, are perforated with many holes, through which, as well as from their tops, the flame may be directed inwards and downwards; *s* are the vents for carrying off the flames into the upper space *u*, which is usually left empty. These vents can be closed by iron damper-plates, pushed in through the side-slits of the dome. *t*, *t*, are peep-holes, for observing the state of ignition in the furnace; but they are most commonly bricked up. *Fig.* 1071 is a vertical section, and *fig.* 1072, a plan of an excellent kiln for baking clay to a stony consistence, for the above purpose, or for burning of bricks. A, is the lower; B, the middle; C, the upper kiln; and E, the hood, terminating in the chimney; *a*, *a*, is the ash-pit; *b*, *b*, the vault for raking out the ashes; it is covered with an iron door *c*. *d*, is the peep-hole, filled with a clay stopper; *e*, is the fire-place; *f*, *f*, a vent in the middle of each arch; *g*, *g*, flues at the sides of the arches, situated between the two fire-places; *h*, *i*, *k*, are apertures for introducing the articles to be baked; *l*, a grate for the fire in the uppermost kiln; *m*, the ash-pit; *n*, the fire-door; *o*, openings through which the flames of a second fire are thrown in. At first, only the ground kiln A, is fired, with cleft billets of pine-wood, introduced at the opening *e*; when this is finished, the second is fired; and then the third, in like manner. This kiln is very like the porcelain kiln of Sèvres, and is employed in many places for baking stoneware.

1069



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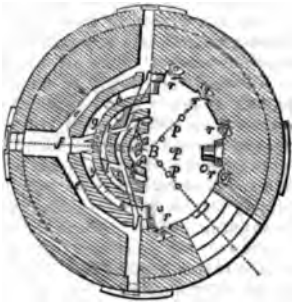

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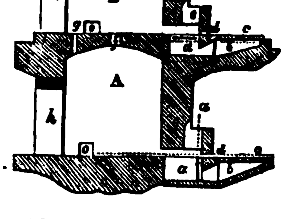

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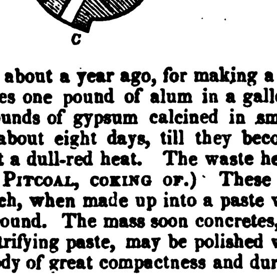


Mr. Keene obtained a patent, about a year ago, for making a factitious stone-paste in the following way:—He dissolves one pound of alum in a gallon of water, and in this solution he soaks eighty-four pounds of gypsum calcined in small lumps. He exposes these lumps in the open air for about eight days, till they become apparently dry, and then calcines them in an oven at a dull-red heat. The waste heat of a coke oven is well adapted for this purpose. (See PITCOAL, COKING OF.) These lumps being ground and sifted, afford a fine powder, which, when made up into a paste with the proper quantity of water, forms the petrifying ground. The mass soon concretes, and after being brushed over with a thin layer of the petrifying paste, may be polished with pumice, &c., in the usual way. It then affords a body of great compactness and durability. If half a pound of copperas be added to the solution of the alum, the gypsum paste, treated as above, has a fine cream or yellow color. This stone stands the weather well.

STONEWARE. (*Fayence*, Fr.; *Steingut*, Germ.) See POTTERY.

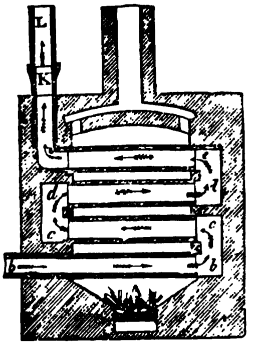
STORAX, STYRAX, flows from the twigs and the trunk of the *Liquidamber styraciflua*, a tree which grows in Louisiana, Virginia, and Mexico. Liquidamber, as this resin is also called, is a brown or ash-gray substance, of the consistence of turpentine, which dries up rapidly, has an agreeable smell, like benzoin, and a bitterish, sharp, burning taste. It dissolves in four parts of alcohol, and affords 1·4 per cent. of benzoic acid.

STOVE (*Poêle, Calorifère*, Fr.; *Ofen*, Germ.), is a fire-place, more or less close, for warming apartments. When it allows the burning coals to be seen, it is called a stove-grate. Hitherto stoves have rarely been had recourse to in this country for heating our sitting-rooms; the cheerful blaze and ventilation of an open fire being generally preferred. But last winter, by its inclemency, gave birth to a vast multitude of projects for increasing warmth and economizing fuel, many of them eminently insalubrious, by preventing due renewal of the air, and by the introduction of noxious fumes into it. When coke is burned very slowly in an iron box, the carbonic acid gas which is generated, being half as heavy again as the atmospherical air, cannot ascend in the chimney at the temperature of 300° F.; but regurgitates into the apartment through every pore of the stove, and poisons the atmosphere. The large stoneware stoves of France and Germany are free from this vice; because, being fed with fuel from the outside, they cannot produce a reflux of carbonic acid into the apartment, when their draught becomes feeble, as inevitably results from the obscurely burning stoves which have the doors of the fire-place and ash-pit immediately above the hearth-stone.

I have recently performed some careful experiments upon this subject, and find that when the fuel is burning so slowly in the stove as not to heat the iron surface above the 250th or 300th degree of Fahr., there is a constant deflux of carbonic acid gas from the ash-pit into the room. This noxious emanation is most easily evinced by applying the beak of a matrass, containing a little Goulard's extract (solution of subacetate of lead), to a round hole in the door of the ash-pit of a stove in this languid state of combustion. In a few seconds the liquid will become milky, by the reception of carbonic acid gas. I shall be happy to afford ocular demonstration of this fact to any incredulous votary of the pseudo-economical, anti-ventilation stoves, now so much in vogue. There is no mode in which the health and life of a person can be placed in more insidious jeopardy, than by sitting in a room with its chimney closed up with such a choke-damp-vomiting stove.

That fuel may be consumed by an obscure species of combustion, with the emission of very little heat, was clearly shown in Sir H. Davy's *Researches on Flame*. "The facts detailed on insensible combustion," says he, "explain why so much more heat is obtained from fuel when it is burned quickly, than slowly; and they show that, in all cases, the temperature of the acting bodies should be kept as high as possible; not only because the general increment of heat is greater, but likewise because those combinations are prevented, which, at lower temperatures, take place without any considerable production of heat. These facts likewise indicate the source of the great error into which experimenters have fallen, in estimating the heat given out in the combustion of charcoal; and they indicate methods by which the temperature may be increased, and the limits to certain methods." These conclusions are placed in a strong practical light by the following simple experiments:—I set upon the top orifice of a small cylindrical stove, a hemispherical copper pan, containing six pounds of water, at 60° F., and burned briskly under it three and a half pounds of coke in an hour; at the end of which time, four and a half pounds of water were boiled off. On burning the same weight of coke *slowly* in the same furnace, mounted by the same pan, in the course of twelve hours, little more than one half the quantity of water was exhaled. Yet, in the first case, the aerial products of combustion swept so rapidly over the bottom of the pan, as to communicate to it not more than one fourth of the effective heat which might have been obtained by one of the plans described in the article Evaporation; while in the second case, these products moved at least twelve times more slowly across the bottom of the pan, and ought therefore to have been so much the more effective in evaporation, had they possessed the same power or quantity of heat.

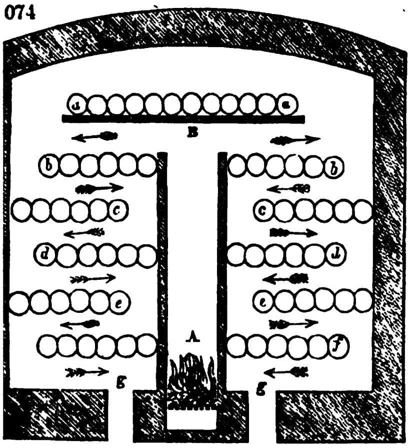
1073



Stoves, when properly constructed, may be employed both safely and advantageously to heat entrance-halls upon the ground story of a house; but care should be taken not to vitiate the air by passing it over ignited surfaces, as is the case with most of the patent stoves now foisted upon the public. *Fig.* 1073 exhibits a vertical section of a stove which has been recommended for power and economy; but it is highly objectionable, as being apt to scorch the air. The flame of the fire A, circulates round the horizontal pipes of cast-iron, *b*, *b*, *c*, *c*, *d*, *d*, *e*, *e*, which receive the external air at the orifice *b*, and conduct it up through the series, till it issues highly heated at K, L, and may be thence conducted wherever it is wanted. The smoke escapes through the chimney B. This stove has evidently two prominent faults; first, it heats the air-pipes very unequally, the undermost far too much; secondly, the air, by the time it has ascended through zigzag range to the pipe *e e*, will be nearly of the same temperature with it, and will efore abstract none of its heat. Thus the upper pipes, if there be several in the range, be quite inoperative, wasting their warmth upon the sooty air.

ig. 1074 exhibits a transverse vertical section of a far more economical and powerful e, in which the above evils are avoided. The products of combustion of the fire A, rise up between two brick walls, so as to play upon the bed of tiles B, where, after communicating a moderate heat to the series of slanting pipes whose areas are represented by the small circles, *a*, *a*, they turn to the right and left, and circulate round the successive rows of pipes *b b*, *c c*, *d d*, *e e*, and finally escape at the bottom by the flues *g*, *g*, pursuing a somewhat similar path to that of the burned air among a bench of gas-light retorts. It is known, that two thirds of the fuel have been saved in the gas-works by this distribution of the furnace. For the purpose of heating apartments, the great object is to supply a vast body of genial air; and, therefore, merely such a moderate fire should be kept up in A, as will suffice to warm all the pipes pretty equably to temperature of 220° Fahr.; and, indeed, as they are laid with a slight slope, are open he air at their under ends, and terminate at the upper in a common main pipe or tun- , they can hardly be rendered very hot by any intemperance of firing. I can safely ommend this stove to my readers. If the tubes be made of stoneware, its construction l cost very little; and they may be made of any size, and multiplied so as to carry off whole effective heat of the fuel, leaving merely so much of it in the burned air, as to t it fairly up the chimney.

074



shall conclude this article by a short extract of a paper which was read before the al Society, on the 16th of June, 1836, *upon warming and ventilating apartments*; a ject to which my mind had been particularly turned at that time, by the Directors the Customs Fund of Life Assurance, on account of the very general state of indis- ition and disease prevailing among those of their officers (nearly 100 in number) en- ed on duty in the Long Room of the Custom House, London.

'The symptoms of disorder experienced by the several gentlemen (about twenty in nber) whom I examined, out of a great many who were indisposed, were of a very form character. The following is the result of my researches:—

'A sense of tension or fulness of the head, with occasional flushings of the coun- ance, throbbing of the temples, and vertigo, followed, not unfrequently, with a con- ion of ideas, very disagreeable to officers occupied with important and sometimes icate calculations. A few are affected with unpleasant perspiration on their sides. e whole of them complain of a remarkable coldness and languor in their extremities, re especially the legs and feet, which has become habitual, denoting languid cir- ation in these parts, which requires to be counteracted by the application of warm nnels on going to bed. The pulse is, in many instances, more feeble, frequent, sharp, l irritable, than it ought to be, according to the natural constitution of the individuals. e sensations in the head occasionally rise to such a height, notwithstanding the most nperate regimen of life, as to require cupping, and at other times depletory remedies. stiveness, though not a uniform, is yet a prevailing symptom.

'The sameness of the above ailments, in upwards of one hundred gentlemen, at very ious periods of life, and of various temperaments, indicates clearly sameness in the ise.

'The temperature of the air in the Long Room ranged, in the three days of my expe- iental inquiry, from 62° to 64° of Fahrenheit's scale; and in the Examiner's Room it s about 60°, being kept somewhat lower by the occasional shutting of the hot-air ve, which is here placed under the control of the gentlemen; whereas that of the ng Room is designed to be regulated in the sunk story, by the fireman of the stove, o seems sufficiently careful to maintain an equable temperature amidst all the vicis- ides of our winter weather. Upon the 7th of January, the temperature of the open air was 50°; and on the 11th it was only 35°; yet upon both days the thermometer in the Long Room indicated the same heat, of from 62° to 64°.

"The hot air discharged from the two cylindrical stove-tunnels into the Long Room was at 90° upon the 7th, and at 110° upon the 11th. This air is diluted, however, and disguised, by admixture with a column of cold air, before it is allowed to escape. The air, on the contrary, which heats the Examiner's Room, undergoes no such mollification, and comes forth at once in an ardent blast of fully 170°; not unlike the simoom of the desert, as described by travellers. Had a similar nuisance, on the greater scale, existed in the Long Room, it could not have been endured by the merchants and other visitors on business: but the disguise of an evil is a very different thing from its removal. The direct air of the stove, as it enters the Examiner's Room, possesses, in an eminent degree, the disagreeable smell and flavor imparted to air by the action of red-hot iron; and, in spite of every attention on the part of the fireman to sweep the stove apparatus from time to time, it carries along with it abundance of burned dusty particles.

"The leading characteristic of the air in these two rooms, is its dryness and disagreeable smell. In the Long Room, upon the 11th, the air indicated, by Daniell's hygrometer, 70 per cent. of dryness, while the external atmosphere was nearly saturated with moisture. The thermometer connected with the dark bulb of that instrument stood at 30° when dew began to be deposited upon it; while the thermometer in the air stood at 64°. In the court behind the Custom-house, the external air being at 35°, dew was deposited on the dark bulb of the hygrometer by a depression of only 3°; whereas in the Long Room, on the same day, a depression of 34° was required to produce that deposition. Air, in such a dry state, would evaporate 0·44 in depth of water from a cistern in the course of twenty-four hours; and its influence on the cutaneous exhalants must be proportionably great.

"As cast iron always contains, besides the metal itself, more or less carbon, sulphur, phosphorus, or even arsenic, it is possible that the smell of air passed over it in an incandescent state, may be owing to some of these impregnations; for a quantity of noxious effluvia, inappreciably small, is capable of affecting not only the olfactory nerves, but the pulmonary organs. I endeavored to test the air as it issued from the valve in the Examiner's Room, by presenting to it pieces of white paper moistened with a solution of nitrate of silver, and perceived a slight darkening to take place, as if by sulphurous fumes. White paper, moistened with sulphureted hydrogen water, was not in the least discolored. The faint impression on the first test paper, may be, probably, ascribed to sulphurous fumes, proceeding from the ignition of the myriads of animal and vegetable matters which constantly float in the atmosphere, as may be seen in the sunbeam admitted into a dark chamber: to this cause, likewise, the offensive smell of air, transmitted over red-hot iron, may in some measure be attributed, as well as to the hydrogen resulting from the decomposition of aqueous vapor, always present in our atmosphere in abundance; especially close to the banks of the Thames, below London Bridge.

"When a column of air sweeps furiously across the burning deserts of Africa and Arabia, constituting the phenomenon called simoom by the natives, the air becomes not only very hot and dry, but highly electrical, as is evinced by lightning and thunder. Dry sands, devoid of vegetation, cannot be conceived to communicate any noxious gas or vapor to the atmosphere, like the malaria of marshes, called miasmata; it is, hence, highly probable that the blast of the simoom owes its deadly malignity, in reference to animal as well as vegetable life, simply to extreme heat, dryness, and electrical disturbance. Similar conditions, though on a smaller scale, exist in what is called the bell, or cockle, apparatus for heating the Long Room and the Examiner's apartment in the Custom-house. It consists of a series of inverted, hollow, flattened pyramids of cast iron, with an oblong base, rather small in their dimensions, to do their work sufficiently in cold weather, when moderately heated. The inside of the pyramids is exposed to the flames of coke furnaces, which heat them frequently to incandescence, while currents of cold air are directed to their exterior surfaces by numerous sheet-iron channels. The incandescence of these pyramids, or bells, as they are vulgarly called, was proved by pieces of paper taking fire when I laid them on the summits. Again, since air becomes electrical when it is rapidly blown upon the surfaces of certain bodies, it occurred to me that the air which escapes into the Examiner's Room might be in this predicament. It certainly excites the sensation of a cobweb playing round the head, which is well known to all who are familiar with electrical machines. To determine this point, I presented a condensing gold-leaf electrometer to the said current of hot air, and obtained faint divergence with negative electricity. The electricity must be impaired in its tension, however, in consequence of the air escaping through an iron grating, and striking against the flat iron valves, both of which tend to restore the electric equilibrium. The air blast, moreover, by being diffused round the glass of the condenser apparatus, would somewhat mask the appearances. Were it worth while, an apparatus might be readily constructed for determining this point, without any such sources of fallacy. The influence of an atmosphere charged with electricity in exciting headache and confusion of thought in many persons, is universally known.

"The fetid burned odor of the stove air, and its excessive avidity for moisture, are of themselves, however, sufficient causes of the general indisposition produced among the gentlemen who are permanently exposed to it in the discharge of their public duties.

"From there being nearly a vacuum, as to aqueous vapor, in the said air, while there is nearly a plenum in the external atmosphere round about the Custom-house, the vicissitudes of feeling in those who have occasion to go out and in frequently, must be highly detrimental to health. The permanent action of an artificial desiccated air on the animal economy may be stated as follows:—

"The living body is continually emitting a transpirable matter, the quantity of which, in a grown up man, will depend partly on the activity of the cutaneous exhalants, and partly on the relative dryness or moisture of the circumambient medium. Its average amount, in common circumstances, has been estimated at 20 ounces in twenty-four hours.

"When plunged in a very dry air, the insensible perspiration will be increased; and, as it is a true evaporation or gasefaction, it will generate cold proportionably to its amount. Those parts of the body which are most insulated in the air, and furthest from the heart, such as the extremities, will feel this refrigerating influence most powerfully. Hence the coldness of the hands and feet, so generally felt by the inmates of the apartment, though its temperature be at or above 60°. The brain, being screened by the skull from this evaporating influence, will remain relatively hot, and will get surcharged, besides, with the fluids which are repelled from the extremities by the condensation, or contraction, of the blood-vessels, caused by cold. Hence the affections of the head, such as tension, and its dangerous consequences. If sensible perspiration happen, from debility, to break forth from a system previously relaxed, and plunged into dry air, so attractive of vapor, it will be of the kind called a cold clammy sweat on the sides and back, as experienced by many inmates of the Long Room.

"Such, in my humble apprehension, is a rationale of the phenomena observed at the Custom-house. Similar effects have resulted from hot-air stoves of a similar kind in many other situations.

"After the most mature physical and medical investigation, I am of opinion that the circumstances above specified cannot act permanently upon human beings, without impairing their constitutions, and reducing the value of their lives. The Directors of the Customs Fund are therefore justified in their apprehensions, 'that the mode of heating the Long Room is injurious to the health of persons employed therein, and that it must unduly shorten the duration of life.'

"It may be admitted, as a general principle, that the comfort of sedentary individuals, occupying large apartments during the winter months, cannot be adequately secured by the mere influx of hot air from separate stove rooms: it requires the genial influence of radiating surfaces in the apartments themselves, such as of open fires, of pipes, or other vessels filled with hot water or steam. The clothing of our bodies, exposed to such radiation in a pure, fresh, somewhat cool and bracing air, absorbs a much more agreeable warmth than it could acquire by being merely immersed in an atmosphere heated even to 62° Fahr., like that of the Long Room. In the former predicament, the lungs are supplied with a relatively dense air, say at 52° Fahr.; while the external surface of the body or the clothing is maintained at, perhaps, 70° or 75°. This distinctive circumstance has not, I believe, been hitherto duly considered by the stove doctors, each intent on puffing his own pecuniary interest; but it is obviously one of great importance, and which the English people would do well to keep in view; because it is owing to our domestic apartments being heated by open fires, and our factories by steam pipes, that the health of our population, and the expectation of life among all orders in this country, are so much better than in France and Germany, where hot-air stoves, neither agreeable nor inoffensive, and in endless variety of form, are generally employed.

"In conclusion, I take leave to state to you my firm conviction that the only method of warming your Long Room and subsidiary apartments, combining salubrity, safety, and economy, with convenience in erection and durable comfort in use, is by a series of steam pipes laid along the floor, at the line of the desk partitions, in suitable lengths, with small arched junction-pipes rising over the several doorways, to keep the passages clear, and at the same time to allow a free expansion and contraction in the pipes, thereby providing for the permanent soundness of the joints."

It would not be difficult to construct a stove or stove-grate which should combine economy and comfort of warming an apartment, with briskness of combustion and durability of the fire, without any noxious deflux of carbonic acid. See CHIMNEY.

STRASS; see PASTES.

STRAW-HAT MANUFACTURE. The mode of preparing the Tuscany or Italian straw, is by pulling the bearded wheat while the ear is in a soft milky state, the corn having been sown very close, and of consequence produced in a thin, short, and dwindled condition. The straw, with its ears and roots, is spread out thinly upon the ground in fine hot weather, for three or four days or more, in order to dry the sap; it is then tied up in bundles and stacked, for the purpose of enabling the heat of the mow to drive off any remaining moisture. It is important to keep the ends of the straw air-tight, in order to retain the pith, and prevent its gummy particles from passing off by evaporation.

After the straw has been about a month in the mow, it is removed to a meadow and spread out, that the dew may act upon it, together with the sun and air, and promote the bleaching, it being necessary frequently to turn the straw while this process is going on. The first process of bleaching being complete, the lower joint and root is pulled from the straw, leaving the upper part fit for use, which is then sorted according to qualities; and after being submitted to the action of steam, for the purpose of extracting its color, and then to a fumigation of sulphur, to complete the bleaching, the straws are in a condition to be platted or woven into hats and bonnets, and are in that state imported into England in bundles, the dried ears of the wheat being still on the straw.

Straw may be easily bleached by a solution of chloride of lime, and also by sulphuring. For the latter purpose, a cask open at both ends, with its seams papered, is to be set upright a few inches from the ground, having a hoop nailed to its inside, about six inches beneath the top, to support another hoop with a net stretched across it, upon which the straw is to be laid in successive handfuls loosely crossing each other. The cask having been covered with a tight overlapping lid, stuffed with lists of cloth, a brasier of burning charcoal is to be inserted within the bottom, and an iron dish containing pieces of brimstone is to be put upon the brasier. The brimstone soon takes fire, and fills the cask with sulphurous acid gas, whereby the straw gets bleached in the course of three or four hours. Care should be taken to prevent such a violent combustion of the sulphur as might cause black burned spots, for these cannot be afterwards removed. The straw, after being aired and softened by spreading it upon the grass for a night, is ready to be split, preparatory to dyeing. Blue is given by a boiling-hot solution of indigo in sulphuric acid, called *Saxon blue*, diluted to the desired shade; yellow, by decoction of turmeric; red, by boiling hanks of coarse scarlet wool in a bath of weak alum water, containing the straw; or directly, by cochineal, salt of tin, and tartar. Brazil wood and archil are also employed for dyeing straw. For the other colors, see their respective titles in this Dictionary.

STRETCHING MACHINE. Cotton goods and other textile fabrics, either white or printed, are prepared for the market by being stretched in a proper machine, which lays all their warp and woof yarns in truly parallel positions. A very ingenious and effective mechanism of this kind was made the subject of a patent by Mr. Samuel Morand, of Manchester, in April, 1834, which serves to extend the width of calico pieces, or of other cloths woven of cotton, wool, silk, or flax, after they have become shrunk in the processes of bleaching, dyeing, &c. I regret that the limits of this volume will not admit of its description. The specification of the patent is published in Newton's Journal, for December, 1835.

STRONTIA, one of the alkaline earths, of which *strontium* is the metallic basis, occurs in a crystalline state, as a carbonate, in the lead mines of Strontian in Argyleshire, whence its name. The sulphate is found crystallized near Bristol, and in several other parts of the world; but strontitic minerals are rather rare. The pure earth is prepared exactly like baryta, from either the carbonate or the sulphate. It is a grayish-white powder, infusible in the furnace, of a specific gravity approaching that of baryta, having an acrid, burning taste, but not so corrosive as baryta, though sharper than lime. It becomes hot when moistened, and slakes into a pulverulent hydrate, dissolves in 150 parts of water at 60°, and in much less at the boiling point, forming an alkaline solution called *strontia* water, which deposites crystals in four-sided tables as it cools. These contain 68 per cent. of water, are soluble in 52 parts of water at 60°, and in about 2 parts of boiling water; when heated they part with 53 parts of water, but retain the other 15 parts, even at a red heat. The dry earth consists of 84·55 of base, and 15·45 of oxygen. It is readily distinguished from baryta, by its inferior solubility, and by its soluble salts giving a red tinge to flame, while those of baryta give a yellow tinge. Fluosilicic acid and iodate of soda precipitate the salts of the latter earth, but not those of the former. The compounds of strontia are not poisonous, like those of baryta. The only preparation of strontia used in the arts is the NITRATE, which see.

STRYCHNIA is an alkaline base, extracted from the *Strychnos nux vomica*, *Strychnos ignatia*, and the *Upas tiente*; which has been employed in medicine by some of the poison doctors, but is of no use in any of the arts. When introduced into the stomach, strychnia acts with fearful energy, causing lock-jaw immediately, and the death of the animal in a very short time. Half a grain, blown into the throat of a rabbit, proves fatal in five minutes.

STUCCO. See GYPSUM.

SUBERIC ACID, is prepared by digesting grated cork with nitric acid. It forms crystals, which sublime in white vapors when heated.

SUBLIMATE, is any solid matter resulting from condensed vapors, and,

SUBLIMATION, is the process by which the volatile particles are raised by heat, and condensed into a crystalline mass. See CALOMEL and SAL-AMMONIAC, for examples.

SUBSALT, is a salt in which the base is not saturated with acid; as subacetate of lead.

SUCCINIC ACID, *Acid of amber* (*Acide succinique*, Fr.; *Bernsteinsaüre*, Germ.), is obtained by distilling coarsely pounded amber in a retort by itself, with a heat gradually raised; or mixed with one twelfth of its weight of sulphuric acid, diluted with half its weight of water. The acid which sublimes is to be dissolved in hot water, to be saturated with potassa or soda, boiled with bone black, to remove the foul empyreumatic oily matter, filtered, and precipitated by nitrate of lead, to convert it into an insoluble succinate; which being washed, is to be decomposed by the equivalent quantity of sulphuric acid. Pure succinic acid forms transparent prisms. The succinate of ammonia is an excellent reagent for detecting and separating iron.

SUGAR (*Sucre*, Fr.; *Zucker*, Germ.), is the sweet constituent of vegetable and animal products. It may be distinguished into two principal species. The first, which occurs in the sugar-cane, the beet-root, and the maple, crystallizes in oblique four-sided prisms, terminated by two-sided summits; it has a sweetening power which may be represented by 100; and in circumpolarization it bends the luminous rays to the right. The second occurs ready formed in ripe grapes and other fruits; it is also produced by treating starch with diastase or sulphuric acid. This species forms cauliflower concretions, but not true crystals; it has a sweetening power which may be represented by 60, and in circumpolarization it bends the rays to the left. Besides these two principal kinds of sugar, some others are distinguished by chemists; as the sugar of milk, of manna, of certain mushrooms, of liquorice-root, and that obtained from saw-dust and glue by the action of sulphuric acid; but they have no importance in a manufacturing point of view.

Sugar, extracted either from the cane, the beet, or the maple, is identical in its properties and composition, when refined to the same pitch of purity; only that of the beet seems to surpass the other two in cohesive force, since larger and firmer crystals of it are obtained from a clarified solution of equal density. It contains 5·3 per cent. of combined water, which can be separated only by uniting it with oxyde of lead, into what has been called a saccharate; made by mixing sirup with finely ground litharge, and evaporating the mixture to dryness upon a steam-bath. When sugar is exposed to a heat of 400° F., it melts into a brown pasty mass, but still retains its water of composition. Sugar thus fused is no longer capable of crystallization, and is called caramel by the French. It is used for coloring liqueurs. Indeed, sugar is so susceptible of change by heat, that if a colorless solution of it be exposed for some time to the temperature of boiling water, it becomes brown and partially uncrystallizable. Acids exercise such an injurious influence upon sugar, that after remaining in contact with it for a little while, though they be rendered thoroughly neutral, a great part of the sugar will refuse to crystallize. Thus, if three parts of oxalic or tartaric acid be added to sugar in solution, no crystals of sugar can be obtained by evaporation, even though the acids be neutralized by chalk or carbonate of lime. By boiling cane sugar with dilute sulphuric acid, it is changed into starch sugar. Manufacturers of sugar should be, therefore, particularly watchful against every acidulous taint or impregnation. Nitric acid converts sugar into oxalic and malic acids. Alkaline matter is likewise most detrimental to the grain of sugar; as is always evinced by the large quantity of molasses formed, when an excess of temper lime has been used in clarifying the juice of the cane or the beet. When one piece of lump sugar is rubbed against another in the dark, a phosphorescent light is emitted.

Sugar is soluble in all proportions in water; but it takes four parts of spirits of wine, of spec. grav. 0·830, and eighty of absolute alcohol, to dissolve it, both being at a boiling temperature. As the alcohol cools, it deposites the sugar in small crystals. Caramelized and uncrystallizable sugar dissolves readily in alcohol. Pure sugar is unchangeable in the air, even when dissolved in a good deal of water, if the solution be kept covered and in the dark; but with a very small addition of gluten, the solution soon begins to ferment, whereby the sugar is decomposed into alcohol and carbonic acid, and ultimately into acetic acid.

Sugar forms chemical compounds with the salifiable bases. It dissolves readily in caustic potash ley, whereby it loses its sweet taste, and affords on evaporation a mass which is insoluble in alcohol. When the ley is neutralized by sulphuric acid, the sugar recovers its sweet taste, and may be separated from the sulphate of potash by alcohol, but it will no longer crystallize.

That sirup possesses the property of dissolving the alkaline earths, lime, magnesia, strontites, barytes, was demonstrated long ago by Mr. Ramsay of Glasgow, by experiments published in Nicholson's Journal, volume xviii. page 9, for September, 1807. He found that sirup is capable of dissolving half as much lime as it contains of sugar; and as much strontites as sugar. Magnesia dissolved in much smaller quantity, and barytes, seemed to decompose the sugar entirely. These results have been since confirmed by Professor Daniell. Mr. Ramsay characterized sugar treated with lime as weak, from its sweetening power being impaired; from its solution he obtained, after some time, a deposite of calcareous carbonate. M. Pelouze has lately shown, that the carbonic acid in this case is derived from the atmosphere, and is not formed at the expense of the elements of the sugar, as Mr. Daniell had asserted.

Sugar forms with oxyde of lead two combinations; the one soluble, the other insoluble. Oxyde of lead digested in sirup dissolves to a certain amount, forms a yellowish liquor, which possesses an alkaline reaction, and leaves after evaporation an uncrystallizable, viscid, deliquescent mass. If sirup be boiled with oxyde of lead in excess, if the solution be filtered boiling hot, and if the vial be corked in which it is received, white bulky flocks will fall to its bottom in the course of 24 hours. This compound is best dried *in vacuo*. It is in both cases light, tasteless, and insoluble in cold and boiling water; it takes fire like German tinder, (AMADOU,) when touched at one point with an ignited body, and burns away, leaving small globules of lead. It dissolves in acids, and also in neutral acetate of lead, which forms with the oxyde a subsalt, and sets the sugar free. Carbonic acid gas passed through water, in which the above saccharate is diffused, decomposes it with precipitation of carbonate of lead. It consists of 58·26 parts of oxyde of lead, and 41·74 sugar, in 100 parts. From the powerful action exercised upon sugar by acids and oxyde of lead, we may see the fallacy and danger of using these chemical reagents in sugar-refining. Sugar possesses the remarkable property of dissolving the oxyde, as well as the subacetate of copper, (verdigris,) and of counteracting their poisonous operation. Orfila found that a dose of verdigris, which would kill a dog in an hour or two, might be swallowed with impunity, provided it was mixed with a considerable quantity of sugar. When a solution of sugar is boiled with the acetate of copper, it causes an abundant precipitate of protoxyde of copper; when boiled with the nitrates of mercury and silver, or the chloride of gold, it reduces the respective bases to the metallic state.

The following TABLE shows the quantities of Sugar contained in Sirups of the annexed specific gravities.* It was the result of experiments carefully made.

Experimental specific gravity of solution at 60° F.	Sugar in 100, by weight.	Experimental specific gravity of solution at 60° F.	Sugar in 100, by weight.
1·3260	66·666	1·1045	25·000
1·2310	50·000	1·0905	21·740
1·1777	40·000	1·0820	20·000
1·4400	33·333	1·0685	16·666
1·1340	31·250	1·0500	12·500
1·1250	29·412	1·0395	10·000
1·1110	26·316		

If the decimal part of the number denoting the specific gravity of sirup be multiplied by 26, the product will denote very nearly the quantity of sugar per gallon in pounds weight, at the given specific gravity.†

Sugar has been analyzed by several chemists; the following TABLE exhibits some of their results:—

	Gay Lussac and Thenard.	Berzelius.	Prout.	Ure.	
Oxygen, - -	56·63	49·856	53·35	50·33	in 100.
Carbon, - - -	42·47	43·265	39·99	43·38	—
Hydrogen, - -	6·90	6·875	6·66	6·29	—

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* The author, in minutes of evidence of Molasses Committee of the House of Commons, 1831, p. 142.

† This rule was annexed to an extensive table, representing the quantities of sugar per gallon corresponding to the specific gravities of the sirup, constructed by the author for the Excise, in subserviency to the Beet-root Bill.

Of the sugar cane, and the extraction of sugar from it.—Humboldt, after the most elaborate historical and botanical researches in the New World, has arrived at the conclusion that before America was discovered by the Spaniards, the inhabitants of that continent and the adjacent islands were entirely unacquainted with the sugar canes, with any of our corn plants, and with rice. The progressive diffusion of the cane has been thus traced out by the partisans of its oriental origin. From the interior of Asia it was transplanted first into Cyprus, and thence into Sicily, or possibly by the Saracens directly into the latter island, in which a large quantity of sugar was manufactured in the year 1148. Lafitau relates the donation made by William the Second, king of Sicily, to the convent of St. Benoit, of a mill for crushing sugar canes, along with all its privileges, workmen, and dependencies: which remarkable gift bears the date of 1166. According to this author, the sugar cane must have been imported into Europe at the period of the Crusades. The monk Albertus Aquensis, in the description which he has given of the processes employed at Acre and at Tripoli to extract sugar, says, that in the Holy Land, the Christian soldiers being short of provisions, had recourse to sugar canes, which they chewed for subsistence. Towards the year 1420, Dom Henry, regent of Portugal, caused the sugar cane to be imported into Madeira from Sicily. This plant succeeded perfectly in Madeira and the Canaries; and until the discovery of America these islands supplied Europe with the greater portion of the sugar which it consumed.

The cane is said by some to have passed from the Canaries into the Brazils; but by others, from the coast of Angola in Africa, where the Portuguese had a sugar colony. It was transported in 1506, from the Brazils and the Canaries, into Hispaniola or Hayti, where several crushing-mills were constructed in a short time. It would appear, moreover, from the statement of Peter Martyr, in the third book of his first Decade, written during the second expedition of Christopher Columbus, which happened between 1493 and 1495, that even at this date the cultivation of the sugar cane was widely spread in St. Domingo. It may therefore be supposed to have been introduced here by Columbus himself, at his first voyage, along with other productions of Spain and the Canaries, and that its cultivation had come into considerable activity at the period of his second expedition. Towards the middle of the 17th century, the sugar cane was imported into Barbadoes from Brazil, then into the other English West Indian possessions, into the Spanish Islands on the coast of America, into Mexico, Peru, Chile, and, last of all, into the French, Dutch, and Danish colonies.

The sugar cane, *Arundo saccharifera*, is a plant of the graminiferous family, which varies in height from 8 to 10, or even to 20 feet. Its diameter is about an inch and a half; its stem is dense, brittle, and of a green hue, which verges to yellow at the approach of maturity. It is divided by prominent annular joints of a whitish-yellow color, the plane of which is perpendicular to the axis of the stem. These joints are placed about 3 inches apart; and send forth leaves, which fall off with the ripening of the plant. The leaves are 3 or 4 feet long, flat, straight, pointed, from 1 to 2 inches in breadth, of a sea-green tint, striated in their length, alternate, embracing the stem by their base. They are marked along their edges with almost imperceptible teeth. In the 11th or 12th month of their growth, the canes push forth at their top a sprout 7 or 8 feet in height, nearly half an inch in diameter, smooth, and without joints, to which the name *arrow* is given. This is terminated by an ample panicle, about 2 feet long, divided into several knotty ramifications, composed of very numerous flowers, of a white color, apetalous, and furnished with 3 stamens, the anthers of which are a little oblong. The roots of the sugar cane are jointed and nearly cylindrical; in diameter they are about one twelfth of an inch; in their utmost length 1 foot, presenting over their surface a few short radicles.

The stem of the cane in its ripe state is heavy, very smooth, brittle, of a yellowish-violet, or whitish color, according to the variety. It is filled with a fibrous, spongy, dirty-white pith, which contains very abundant sweet juice. This juice is elaborated separately in each internodary portion, the functions of which are in this respect independent of the portions above and below. The cane may be propagated by seeds or buds with equal facility; but it is usually done by cuttings or joints of proper lengths, from 15 to 20 inches, in proportion to the nearness of the joints, which are generally taken from the tops of the canes, just below the leaves.

There are several varieties of the sugar-cane plant. The first, and longest known, is the creole, or common sugar cane, which was originally introduced at Madeira. It grows freely in every region within the tropics, on a moist soil, even at an elevation of 3000 feet above the level of the sea. In Mexico, among the mountains of Caudina-Masca, it is cultivated to a height of more than 5000 feet. The quantity and quality of sugar which it yields, is proportional to the heat of the place where it grows, provided it be not too moist and marshy.

The second variety of this plant is the Otaheitan cane. It was introduced into the West Indies about the end of the 18th century. This variety, stronger, taller, with longer spaces between the joints, quicker in its growth, and much more productive in sugar, succeeds perfectly well in lands which seem too much impoverished to grow the ordinary cane. It sends forth shoots at temperatures which chill the growth and development of the creole plant. Its maturation does not take more than a year, and is accomplished sometimes in nine months. From the strength of its stem, and the woodiness of its fibres, it better resists the storms. It displays a better inflorescence, weighs a third more, affords a sixth more juice, and a fourth more sugar, than the common variety. Its main advantage, however, is to yield four crops in the same time that the creole cane yields only three. Its juice contains less feculency and mucilage, whence its sugar is more easily crystallized, and of a fairer color.

Besides these two varieties, another kind is described by Humboldt and Bonpland, under the name of the *violet* sugar-cane, for its haum and leaves are of this color. It was transported from Batavia in 1782. It flowers a month sooner than the rest, that is, in August, but it yields less solid sugar, and more liquid, both of which have a violet tint.

In saying that the cane may be propagated by seeds as well as buds, we must remark, that in all the colonies of the New World, the plant flowers, indeed, but it then sends forth a shoot (*arrow*), that is, its stem elongates, and the seed-vessel proves abortive. For this reason, the bud-joints must there be used for its propagation. It grows to seed, however, in India. This circumstance occurs with some other plants, which, when propagated by their roots, cease to yield fertile seeds; such as the banana, the bread-fruit, the lily, and the tulip.

In the proper season for planting, the ground is marked out by a line into rows three or four feet asunder, in which rows the canes are planted about two feet apart. The series of rows is divided into pieces of land 60 or 70 feet broad, leaving spaces of about 20 feet, for the convenience of passage, and for the admission of sun and air between the stems. Canes are usually planted in trenches, about 6 or 8 inches deep, made with the hand-hoe, the raised soil being heaped to one side, for covering-in the young cane; into the holes a negro drops the number of cuttings intended to be inserted, the digging being performed by other negroes. The earth is then drawn about the hillocks with the hoe. This labor has been, however, in many places better and more cheaply performed by the plough; a deep furrow being made, into which the cuttings are regularly planted, and the mould then properly turned in. If the ground is to be afterwards kept clear by the horse-hoe, the rows of canes should be 5 feet asunder, and the hillocks 2½ feet distant, with only one cane left in one hillock. After some shoots appear, the sooner the horse-hoe is used, the more will the plants thrive, by keeping the weeds under, and stirring up the soil. Plant-canes of the first growth have been known to yield, on the brick-mould of Jamaica, in very fine seasons, 2½ tons of sugar per acre. The proper season for planting the cane slips, containing the buds, namely, the top part of the cane, stripped of its leaves, and the two or three upper joints, is in the interval between August and the beginning of November. Favored by the autumnal weather, the young plants become luxuriant enough to shade the ground before the dry season sets in; thereby keeping the roots cool and moderately moist. By this arrangement the creole canes are ripe for the mill in the beginning of the second year, so as to enable the manager to finish his crop early in June. There is no greater error in the colonist than planting canes at an improper season of the year, whereby his whole system of operations becomes disturbed, and, in a certain degree, abortive.

The withering and fall of a leaf afford a good criterion of the maturity of the cane-joint to which it belonged; so that the eight last leafless joints of two canes, which are cut the same day, have exactly the same age and the same ripeness, though one of the canes be 15 and the other only 10 months old. Those, however, cut towards the end of the dry season, before the rains begin to fall, produce better sugar than those cut in the rainy season, as they are then somewhat diluted with watery juice, and require more evaporation to form sugar. It may be reckoned a fair average product, when one pound of sugar is obtained from one gallon (English) of juice.

Rattoons (a word corrupted from *rejettons*) are the sprouts or suckers that spring from the roots or stoles of the canes that have been previously cut for sugar. They are commonly ripe in 12 months; but canes of the first growth are called plant-canes, being the direct produce of the original cuttings or germs placed in the ground, and require a longer period to bring them to maturity. The first yearly return from the roots that are cut over, are called first rattoons; the second year's growth, second rattoons; and so on, according to their age. Instead of stocking up his rattoons, holing, and planting the land anew, the planter suffers the stoles to continue in the ground, and contents himself, as the cane-fields become thin and impoverished, with supplying the vacant places with fresh plants. By these means, and with the aid of manure, the produce of sugar per acre, if not apparently equal to that from plant-canes, gives perhaps in the long run as great returns to the owner, considering the relative proportion of the labor and expense attending the different systems. The common yielding on proper land, such as the red soil of Trelawney, in Jamaica, is 7 hogsheads, of 16 cwts. each, to 10 acres of rattoons cut annually; and such a plantation lasts from 6 to 10 years.

When the planted canes are ripe, they are cut close above the ground, by an oblique section, into lengths of 3 or 4 feet, and transported in bundles to the mill-house. If the roots be then cut off, a few inches below the surface of the soil, and covered up with fine mould, they will push forth more prolific offsets or rattoons, than when left projecting in the common way.

OF SUGAR MILLS.

The first machines employed to squeeze the canes, were mills similar to those which serve to crush apples in some cider districts, or somewhat like tan-mills. In the centre of a circular area, of about 7 or 8 feet in diameter, a vertical heavy wheel was made to revolve on its edge, by attaching a horse to a cross beam projecting horizontally from it, and making it move in a circular path. The cane pieces were strewed on the somewhat concave bed in the path of the wheel, and the juice expressed flowed away through a channel or gutter in the lowest part. This machine was tedious and unproductive. It was replaced by the vertical cylinder-mill of Gonzales de Velosa; which has continued till modern times, with little variation of external form, but is now generally superseded by the sugar-mill with horizontal cylinders.

SUGAR-CANE MILL.

Specification of, and Observations on, the Construction and Use of the best Horizontal Sugar-mill.

Fig. 1075. Front elevation of the entire mill. *Fig.* 1076. Horizontal plan. *Fig.* 1077. End elevation. *Fig.* 1078. Diagram, showing the dispositions of the feeding and delivering rollers, feeding board, returner, and delivering board.

Fig. 1075. A, A, solid foundation of masonry; B, B, bed plate; C, C, headstocks or standards; D, main shaft (seen only in *fig.* 1076); E, intermediate shaft; F, F, plummer-blocks of main shaft D (seen only in *fig.* 1076); H, driving pinion on the fly-wheel shaft of engine; I, first motion mortise wheel driven by the pinion; K, second motion pinion, on the same shaft; L, second motion mortise-wheel, on the main shaft; M, brays of wood, holding the plummer-blocks for shaft D; N, wrought-iron straps connecting the brays to the standards C, C; O, O, regulating screws for the brays; P, top roller and gudgeons; Q and R, the lower or feeding and delivering rollers; S, clutch for the connexion of the side of lower rollers Q and R, to the main shaft (seen only in *fig.* 1076); T, T, the drain gutters of the mill-bed (seen only in *fig.* 1076).

The same letters of reference are placed respectively on the same parts of the mill in each of *figs.* 1075, 1076, and 1077.

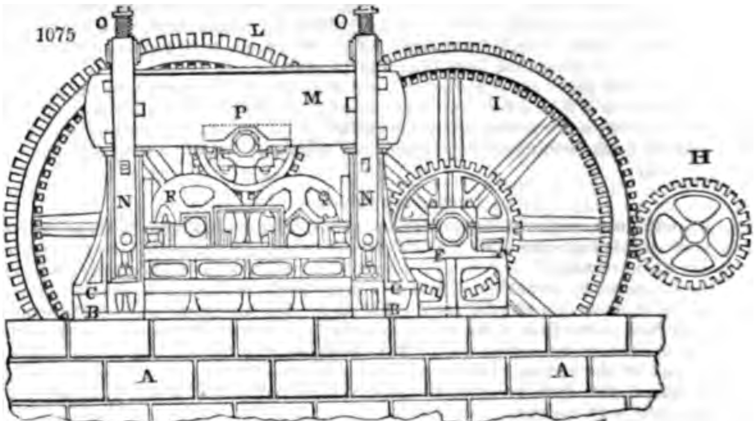
The relative disposition of the rollers is shown in the diagram, *fig.* 1078, in which A is the top roller; B, the feeding roller; C, the delivering roller; D, the returner; E, the feed board; F, the delivering board.

The rollers are made two inches and a quarter to two inches and a half thick, and ribbed in the centre. The feeding and delivering rollers have small flanges at their ends (as shown in *fig.* 1075), between which the top roller is placed; these flanges prevent the pressed canes or begass from working into the mill-bed. The feeding and top rollers are generally fluted, and sometimes diagonally, enabling them the better to seize the canes from the feed-board. It is, however, on the whole, considered better to flute the feeding roller only, leaving the top and delivering rollers plane; when the top roller is fluted, it should be very slightly, for, after the work of a few weeks, its surface becomes sufficiently rough to bite the canes effectively. The practical disadvantage of fluting the delivering rollers, is in the grooves carrying round a portion of liquor, which is speedily absorbed by the spongy begass, as well as in breaking the begass itself, and thus causing great waste.

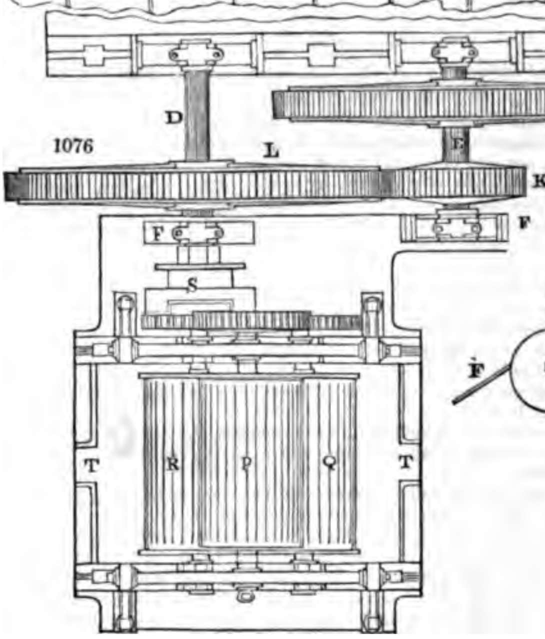
The feed board is now generally made of cast iron, and is placed at a considerable inclination, to allow the canes to slip the more easily down to the rollers. The returner is also of cast iron, serrated on the edge, to admit the free flowing of the liquor to the mill-bed. The concave returner, formerly used, was pierced with holes to drain off the liquor, but it had the serious disadvantage of the holes choking up with the splinters of the cane, and has therefore been discarded. The delivering board is of cast iron, fitted close to the roller, to detach any begass that may adhere to it, and otherwise mix with the liquor.

In Demerara, Surinam, Cayenne, and the alluvial district of Trinidad, it is usual to attach to the mill a liquor-pump, with two barrels and three adjustments of stroke. This

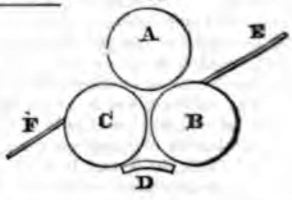
1075



1076



1078

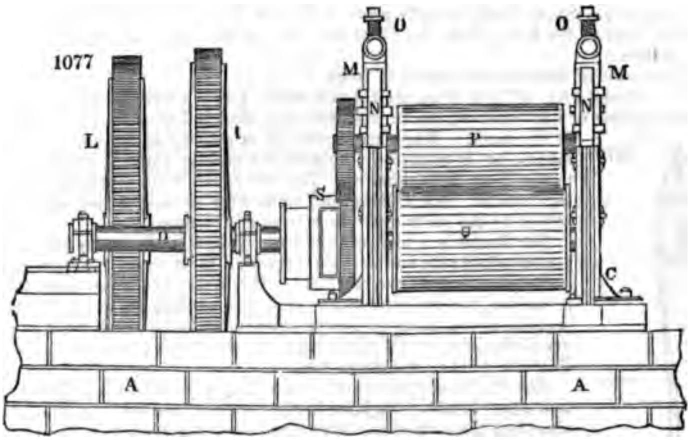


is worked from the gudgeon of the top roller. In action, the liquor from the gutter of the mill-bed runs into the cistern of the pump, and is raised by the pump to the gutter which leads to the clarifier or coppers. Such pumps have brass barrels and copper discharging pipes, are worked with a very slow motion, and require to be carefully adjusted to the quantity of liquor to be raised, which, without such precaution, is either not drawn off sufficiently quick, or is agitated with air in the barrels, and delivered to the gutter in a state of fermentation.

In working this mill, the feeding roller is kept about half an inch distant from the upper roller, but the delivering roller is placed so close to it, as to allow the begass to pass through unbroken.

.The practice with this mill is to cut the sugar canes into short lengths of about three feet, and bring them to the mill tied up in small bundles; there the feeder unites them, throws them on the feed board, and spreads them so that they may cross each other as little as possible. They are taken in by the feed rollers, which split and slightly press them; the liquor flows down, and, the returner guiding the canes between the top and delivering rollers, they receive the final pressure, and are turned out on the mill-floor, while the liquor runs back and falls into the mill-bed. The begass, then in the state of *pith*, adhering to the skin of the cane, is tied up in bundles, and after being exposed a short time to the sun, is finally stored in the begass-house for fuel. By an important improvement in this stage of the process, recently introduced, the begass is carried to the begass-house by a carrier chain, worked by the engine.

1077



The relative merits of horizontal and vertical sugar-mills on this construction may be thus stated:—The horizontal mill is cheaper in construction, and is more easily fixed; the process of feeding is performed at about one half of the labor, and in a much superior manner; the returner guides the canes to receive the last pressure more perfectly; and the begass is not so much broken as in the vertical mill, but left tolerably entire, so as to be tied, dried, and stored, with less trouble and waste.

The vertical mill has a considerable advantage, in being more easily washed; and it can be readily and cheaply mounted in wooden framing; but the great labor of feeding the vertical mill renders it nearly inapplicable to any higher power than that of about ten horses. In situations where the moving power is a windmill, or a cattle-gin, the vertical mill may be preferred.

The scale of produce of such mills varies according to the climate and soil. In Demerara, a well-constructed engine and mill will produce about 100 gallons of liquor per hour for each horse power.

The dimensions of the most approved horizontal mills are these:—

Horse-power of Engine.	Length of Rollers.		Diameter of Rollers.
	ft.	*in.*	*inches.*
8	4	0	25
10	4	6	27
12	4	8	28

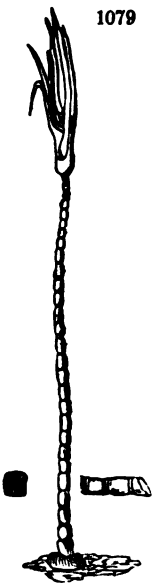
The surface speed of the rollers is 3·4 or 3·6 feet per minute; and to provide for the varying resistance arising from irregular feeding, or the accidental crossing of the canes, by which the engine is often *brought up* so suddenly as to break the fly-wheel shaft, it is necessary to make both the shaft and the fly-wheel of unusual strength and weight.

Sugar is manufactured in the East Indies by two distinct classes of persons; the *ryots*, who raise the sugar cane, extract its juice, and inspissate it to a sirupy consistence; and the *goldars*, who complete the conversion into sugar.

The *ryots* are the farmers, or actual cultivators of the soil; but, properly speaking, they are merely peasants, toiling under oppressive landlords, and miserably poor. After they cut the canes, they extract the juice by one or other of the rude mills or mortars presently to be described, and boil it down to an entire mass, which is generally called *goor*, without making any attempt to clarify it, or separate the granular sugar from the uncrystallizable molasses. This goor is of various qualities; one of which, in most common use for making sugar, is known amongst the English settlers under the name of *jaggery*. There is a caste in Ceylon, called *jaggeraros*, who make sugar from the produce of the *Caryota urens*, or Kitul tree; and the sugar is styled *jaggery*. Sugar is not usually made in Ceylon from the sugar cane; but either from the juice of the Kitul, from the *Cocos nucifera*, or the *Borassus flabelliformis* (the Palmyra tree.)

Several sorts of cane are cultivated in India.

1079



The *Cadjoolee* (*fig.* 1079) is a purple-colored cane; yields a sweeter and richer juice than the yellow or light-colored, but in less quantities, and is harder to press. It grows in dry lands. When eaten raw, it is somewhat dry and pithy in the mouth, but is esteemed very good for making sugar. It is not known to the West India planter. The leaves rise from a point 6 feet above the ground. An oblique and transverse section of the cane is represented by the parts near the bottom of the figure.

The *Pooree* is a light-colored cane, yellow, inclining to white, deeper yellow when ripe and on rich ground. West India planters consider it the same sort as one of theirs. It is softer and more juicy than the preceding, but the juice is less rich, and produces a weaker sugar. It requires seven parts of pooree juice to make as much goor as is produced from six of the cadjoolee. Much of this cane is brought to the Calcutta market, and eaten raw.

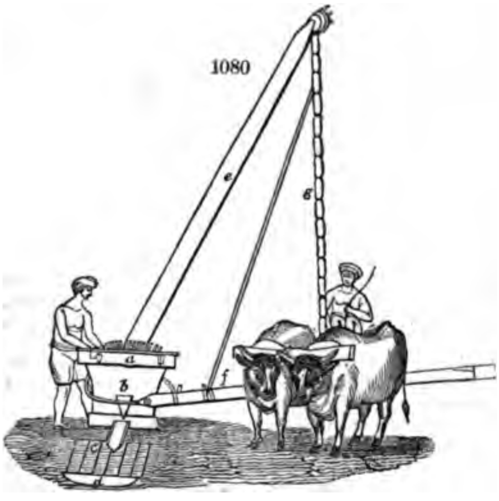
The *Cullorah* thrives in swampy lands, is light-colored, and grows to a great height. Its juice is more watery, and yields a weaker sugar also than the cadjoolee. However, since much of Bengal consists of low grounds, and since the upland canes are apt to suffer from drought, it deserves encouragement in certain localities.

It is only large farms that cut an acre of cane in a year; one mill, therefore, and one set of the implements used in inspissating the juice, although very rude and simple, serve for several farms, and generally belong to some wealthy man, who lets them out for hire to his poorer neighbors, the whole of whom unite to clear each other's fields by turns; so that though many people and cattle are employed at one of these miserable sets of works, very few indeed are hired, and the greater part of the labor is performed by the common stock of the farms.

The inspissated juice, or extract of cane, called by the natives *goor*, is of two kinds; one of which may be termed cake extract, and the other pot extract; both being often denominated *jaggery*, as above stated, by the English residents.

One third of an acre of good land in the southern districts, is reckoned by the farmers to produce 18,891 pounds of cane, and 1,159 pounds of pot extract. Its produce in cake extract is about 952 pounds.

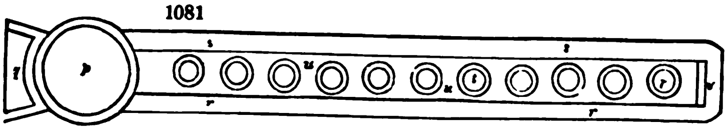
1080



I shall now describe the primitive rude mill and boiler used in preparing the extract of sugar cane, and which are usually let to the ryots by the day. The mill in Dinajpur, *fig.* 1080, is on the principle of a pestle and mortar. The pestle, however, does not beat the canes, but is rubbed against them, as is done in many chemical triturations; and the moving force is two oxen. The mortar is generally a tamarind tree, one end of which is sunk deep in the ground, to give it firmness. The part projecting, *a*, *a*, *a*, *a*, may be about two feet high, and a foot and a half in diameter; and in the upper end a hollow is cut, like the small segment of a sphere. In the centre of this, a channel descends a little way perpendicularly, and then obliquely to one side of the mortar, so that the juice, as squeezed from the cane, runs off, by means of a spout *b*, into a strainer *c*, through which it falls into an earthen pot, that stands in a hole *d*, under the spout. The pestle *e*, is a tree about 18 feet in length, and 1 foot in diameter, rounded at its bottom, which rubs against the mortar, and which is secured in its place by a button or knob, that goes into the channel of the mortar. The moving force is applied to a horizontal beam *f*, about 16 feet in length, which turns round about the mortar, and is fastened to it by a bent bamboo *b*. It is suspended from the upper end of the pestle by a bamboo *g*, which has been cut with part of the root, in which is formed a pivot that hangs on the upper point of the pestle. The cattle are yoked to the horizontal beam, at about ten feet from the mortar, move round it in a circle, and are driven by a man, who sits on the beam, to increase the weight of the triturating power. Scarcely any machine more miserable can be conceived; and it would be totally ineffectual, were not the cane cut into thin slices. This is a troublesome part of the operation. The grinder sits on the ground, having before him a bamboo stake, which is driven into the earth, with a deep notch formed in its upper end. He passes the canes gradually through this notch, and at the same time cuts off the slices with a kind of rude chopper.

The *boiling apparatus* is somewhat better contrived, and is placed under a shed, though the mill is without shelter. The fireplace is a considerable cavity dug in the ground, and covered with an iron boiler *p*, *fig.* 1081. At one side of this, is an opening *q*, for throwing in fuel; and opposite to this, is another opening, which communicates with the horizontal flue. This is formed by two parallel mud walls *r*, *r*, *s*, *s*, about 20 feet long, 2 feet high, and 18 inches distant from each other. A row of eleven earthen boilers *t*, is placed on these walls, and the interstices *u*, are filled with clay, which completes the furnace-flue, an opening *v*, being left at the end, for giving vent to the smoke.

1081



The juice, as it comes from the mill, is first put into the earthen boiler that is most distant from the fire, and is gradually removed from one boiler to another, until it reaches the iron one, where the process is completed. The fireplace is manifestly on the same model as the boiler range in the West Indies, and may possibly have suggested it, since the Hindostan furnace is, no doubt, of immemorial usage. The execution of its parts is very rude and imperfect. The inspissated juice that can be prepared in 24 hours by such a mill, with 16 men and 20 oxen, amounts to no more than 476 lbs.; and it is only in the southern parts of the district, where the people work night and day, that the sugar-works are so productive. In the northern districts, the people work only during the day, and inspissate about one half the quantity of juice. The average daily make of a West India sugar-house, is from 2 to 3 hogsheads, of 16 cwts. each.

The Indian manufacturers of sugar purchase the above inspissated juice or goor from the farmers, and generally prefer that of a granular honey consistence, which is offered for sale in pots. As this, however, cannot conveniently be brought from a distance, some of the cake kind is also employed. The boilers are of two sizes; one adapted for making at each operation about ten cwts.; the other, about eight and a half. The latter is the segment of a sphere, nine feet diameter at the mouth; the former is larger. The boiler is sunk into a cylindrical cavity in the ground, which serves as a fireplace, so that its edge is just above the floor of the boiling-house. The fuel is thrown in by an aperture close to one side of the boiler, and the smoke escapes by a horizontal chimney that passes out on the opposite side of the hut, and has a small round aperture, about ten feet distant from the wall, in order to lessen the danger from fire. Some manufacturers have only one boiler; others as many as four; but each boiler has a separate hut, in one end of which is some spare fuel; and in the other, some bamboo stages, which support cloth strainers, that are used in the operation. This hut is about twenty-four cubits long, and ten broad; has mud walls, six cubits high; and is raised about one cubit above the ground.

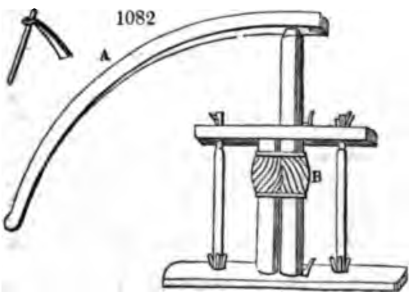
For each boiler, two other houses are required: one in which the cane extract is separated by straining from the molasses, is about twenty cubits long by ten wide; another, about thirty cubits long, by eight wide, is that in which, after the extract has been strained, boiled, and clarified, the treacle is separated from the sugar by an operation analogous to claying.

Each sugar manufacturer has a warehouse besides, of a size proportional to the number of his boilers.

About 960 pounds of pot extract being divided into four parts, each is put into a bag of coarse sackcloth, hung over an equal number of wide-mouthed earthen vessels, and is besprinkled with a little water. These drain from the bags about 240 pounds of a substance analogous to West Indian molasses. The remainder in the bags is a kind of coarse muscovado sugar; but is far from being so well drained and freed from molasses as that of the Antilles. The 720 pounds of this substance are then put into a boiler with 270 pounds of water, and the mixture is boiled briskly for 144 minutes, when 180 additional pounds of water are added, and the boiling is continued for 48 minutes more. An alkaline solution is prepared from the ashes of the plantain tree, strewed over straw placed in the bottom of an earthen pot perforated with holes. Ninety pounds of water are passed through; and 6 pounds of the clear lixivium are added to the boiling sirup, whereby a thick scum is raised, which is removed. After 24 minutes, four and a half pounds of alkaline solution, and about two fifths of a pound of raw milk, are added; after which the boiling and skimming are continued 24 minutes. This must be repeated from five to seven times, until no more scum appears. 240 pounds of water being now added, the liquor is to be poured into a number of strainers. These are bags of coarse cotton cloth, in the form of inverted quadrangular pyramids, each of which is suspended from a frame of wood, about two feet square. The operation of straining occupies about 96 minutes. The strained liquor is divided into three parts: one of these is put into a boiler, with from half a pound to a pound and a half of alkaline solution, one twelfth of a pound of milk, and 12 pounds of water. After having boiled for between 48 and 72 minutes, three quarters of a pound of milk are added, and the liquor is poured, in equal portions, into four refining pots. These are wide at the mouth, and pointed at the bottom; but are not conical, for the sides are curved. The bottom is perforated, and the stem of a plantain leaf forms a plug for closing the aperture. The two remaining portions of the strained liquor are managed in exactly the same manner; so that each refining pot has its share of each portion. When they have cooled a little, the refining pot is removed to the curing-house, and placed on the ground for 24 hours; next day they are placed on a frame, which supports them at some distance from the ground. A wide-mouthed vessel is placed under each, to receive the viscid liquor that drains from them. In order to draw off this more completely, moist leaves of the *Valisneria spiralis* are placed over the mouth of the pot, to the thickness of two inches; after 10 or 12 days, these are removed; when a crust of sugar, about half an inch in thickness, is found on the surface of the boiled liquor. The crust being broken and removed, fresh leaves are repeatedly added, until the whole sugar has formed; which requires from 75 to 90 days. When cake extract is used, it does not require to be strained before it be put into the boiler.

On the above-described operose and preposterous process, it is needless to make any remarks. While it is adhered to with the tenacity of Hindoo habit, the West Indies has no reason to fear the competition of the East, in the manufacture of sugar, provided the former avail themselves of the aids which chemical and mechanical science are ready to supply.

In every part of the Behar and Putna districts, several of the confectioners prepare the coarse article called *shukkur*, which is entirely similar in appearance to the inferior Jamaica sugars. They prepare it by putting some of the thin extract of sugar cane into coarse sackcloth bags, and by laying weights on them, they squeeze out the molasses; a process perfectly analogous to that contemplated in several English patents.


1082

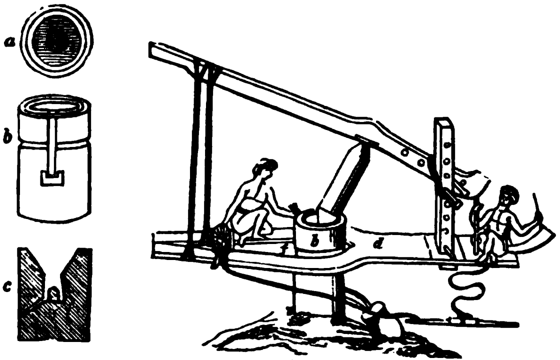
The sugar-mill at Chica Ballapura is worked by a single pair of buffaloes or oxen, *fig.* 1082, going round with the lever A, which is fixed on the top of the right-hand roller. The two rollers have endless screw heads B, which are formed of 4 spiral grooves and 4 spiral ridges, cut in opposite directions, which turn into one another, when the mill is working. These rollers and their heads are of one piece, made of the toughest and hardest wood that can be got, and such as will not impart any bad taste to the juice. They are supported in a thick strong wooden frame, and their distance from each other is regulated by means of wedges, which pass through mortises in the frame planks, and a groove made in a bit of some sort of hard wood, and press upon the axis of one of the rollers. The axis of the other presses against the left-hand side of the hole in the frame-boards. The cane juice runs down the rollers, and through a hole in the lower frame-board, into a wooden conductor, which carries it into an earthen pot. Two long-pointed stakes or piles are driven into the earth, to keep the mill steady, which is all the fixing it requires. The under part of the lowermost plank of the frame rests upon the surface of the ground, which is chosen level and very firm, that the piles may hold the faster. A hole is dug in the earth, immediately below the spout of the conductor, to receive the pot.

The mill used in Burdwan and near Calcutta, is simply two small wooden cylinders, grooved, placed horizontally, close to each other, and turned by two men, one at each end. This simple engine is said completely, but slowly, to express the juice. It is very cheap, the prime cost not being two rupees; and being easily moved from field to field, it saves much labor in the carriage of the cane. Notwithstanding this advantage, so rude a machine must leave a large proportion of the richest juice in the cane-trash.

It is curious to find in the ancient arts of Hindostan exact prototypes of the sugar-rollers, horizontal and upright, of relatively modern invention in the New World.

The sugar-mill of Chinapatam, *fig.* 1083, consists of a mortar, lever, pestle, and regulator. The mortar is a tree about 10 feet in length, and 14 inches in diameter: *a* is a plan of its upper end; *b* is an outside view; and *c* is a vertical section. It is sunk perpendicularly into the earth, leaving one end 2 feet above the surface. The hollow is conical, truncated downwards, and then becomes cylindrical, with a hemispherical projection in its bottom, to allow the juice to run freely to the small opening that conveys it to a spout, from which it falls into an earthen pot. Round the upper mouth of the cone is a circular cavity, which collects any of the juice that may run over from the upper ends of the pieces of cane; and thence a canal conveys this juice, down the outside of the mortar, to the spout. The beam *d*, is about 16 feet in length, and 6 inches in thickness, being cut out from a large tree that is divided by a fork into two arms. In the fork an excavation is made for the mortar *b*, round which the beam turns horizontally. The surface of this excavation is secured by a semi-circle of strong wood. The end towards the fork is quite open, for changing the beam without trouble. On the undivided end of the beam sits the bullock-driver *e*, whose cattle are yoked by a rope which comes from the end of the beam; and they are prevented from dragging out of the circle by another rope, which passes from the yoke to the forked end of the beam. On the arms *f*, a basket is placed, to hold the cuttings of cane; and between this and the mortar sits the man who feeds the mill. Just as the pestle comes round, he places the pieces of cane sloping down into the cavity of the mortar; and after the pestle has passed, he removes those that have been squeezed.

1083



OF THE MANUFACTURE OF SUGAR IN THE WEST INDIES.

Cane-juice varies exceedingly in richness, with the nature of the soil, the culture, the season, and variety of the plant. It is an opaque fluid, of a dull gray, olive, or olive-green color; in taste, balmy and saccharine; exhaling the balsamic odor of the cane; slightly viscid; and of a specific gravity varying from 1·033 to 1·106, according to circumstances. When fresh, it consists of two parts; the one liquid, the other solid; the latter of which being merely suspended in the former, and, therefore, separable in a great measure by filtration or repose. The solid matter consists of fragments of the cellular parenchyma of the cane, its fibres, and bark, mechanically protruded through the mill; mixed with a very abundant greenish substance, like that called *chlorophyle* by chemists.

When left to itself in the colonial climates, the juice runs rapidly into the acetous fermentation; twenty minutes being, in many cases, sufficient to bring on this destructive change. Hence arises the necessity of subjecting it immediately to clarifying processes, speedy in their action. When deprived of its green fecula and glutinous extractive, it is still subject to fermentation; but this is now of the vinous kind. The juice flows from the mill through a wooden gutter lined with lead, and being conducted into the sugar-house, is received in a set of large pans or caldrons, called clarifiers. On estates which make on an average, during crop time, from 15 to 20 hogsheads of sugar a week, three clarifiers, of from 300 to 400 gallons' capacity each, are sufficient. With pans of this dimension, the liquor may be drawn off at once by a stop-cock or syphon, without disturbing the feculencies after they subside. Each clarifier is hung over a separate fire, the flue being furnished with a damper for checking the combustion, or extinguishing it altogether. The clarifiers are sometimes placed at one end, and sometimes in the middle of the house, particularly if it possesses a double set of evaporating pans.

Whenever the stream from the mill cistern has filled the clarifier with fresh juice, the fire is lighted, and the *temper*, or dose of slaked lime, diffused uniformly through a little juice, is added. If an albuminous emulsion be used to promote the clarifying, very little lime will be required; for recent cane-liquor contains no appreciable portion of acid to be saturated. In fact, the lime and alkalis in general, when used in small quantity, seem to coagulate the glutinous extractive matter of the juice, and thus tend to brighten it up. But if an excess of temper be used, the gluten is taken up again by the strong affinity which is known to exist between sugar and lime. Excess of lime may always be corrected by a little alum-water. Where canes grow on a calcareous marly soil, in a favorable season, the saccharine matter gets so thoroughly elaborated, and the glutinous mucilage so completely condensed, that a clear juice and a fine sugar may be obtained without the use of lime.

As the liquor grows hot in the clarifier, a scum is thrown up, consisting of the coagulated feculencies of the cane-juice. The fire is now gradually urged till the temperature approaches the boiling point; to which, however, it must not be suffered to rise. It is known to be sufficiently heated, when the scum rises in blisters, which break into white froth; an appearance observable in about forty minutes after kindling the fire. The damper being shut down, the fire dies out; and after an hour's repose, the clarified liquor is ready to be drawn off into the last and largest in the series of evaporating pans. In the British colonies, these are merely numbered 1, 2, 3, 4, 5, beginning at the smallest, which hangs right over the fire, and is called the *teache;* because in it the trial of the sirup, by *touch*, is made. The flame and smoke proceed in a straight line along a flue to the chimney-stalk at the other end of the furnace. The area of this flue proceeds, with a slight ascent from the fire to the aperture at the bottom of the chimney; so that between the surface of the grate and the bottom of the teache, there is a distance of 28 inches; while between the bottom of the flue and that of the *grand*, No. 5, at the other end of the range, there are barely 18 inches.

In some sugar-houses there is planted, in the angular space between each boiler, a basin, one foot wide and a few inches deep, for the purpose of receiving the scum which thence flows off into the *grand copper*, along a gutter scooped out on the margin of the brick-work. The skimmings of the *grand* are thrown into a separate pan, placed at its side. A large cylindrical *cooler*, about six feet wide and two feet deep, has been placed in certain sugar-works near the teache, for receiving successive charges of its inspissated sirup. Each finished charge is called a skipping, because it is skipped or laded out. The term *striking* is also applied to the act of emptying the *teache*. When upon one skipping of sirup in a state of incipient granulation in the cooler, a second skipping is poured, this second congeries of saccharine particles agglomerates round the first as *nuclei* of crystallization, and produces a larger grain; a result improved by each successive skipping. This principle has been long known to the chemist, but does not seem to have been always properly considered or appreciated by the sugar-planter.

From the above described *cooler*, the sirup is transferred into wooden chests or boxes, open at top, and of a rectangular shape; also called *coolers*, but which are more properly crystallizers or granulators. These are commonly six in number; each being about one foot deep, seven feet long, and five or six feet wide. When filled, such a mass is collected, as to favor slow cooling, and consequent large-grained crystallization. If these boxes be too shallow, the grain is exceedingly injured, as may be easily shown by pouring some of the same sirup on a small tray; when, on cooling, the sugar will appear like a muddy soft sand.

The criterion by which the negro boilers judge of the due concentration of the sirup in the teache, is difficult to describe, and depends almost entirely on the sagacity and experience of the individual. Some of them judge by the appearance of the incipient grain on the back of the cooling ladle; but most decide by "*the touch*," that is, the feel and appearance of a drop of the sirup pressed and then drawn into a thread between the thumb and fore-finger. The thread eventually breaks at a certain limit of extension, shrinking from the thumb to the suspended finger, in lengths somewhat propor-

inspissation of the sirup. But the appearance of granulation in the thread
e considered; for a viscid and damaged sirup may give a long enough thread,
ld almost no crystalline grains when cooled. Tenacity and granular aspect
ore, be both taken into the account, and will continue to constitute the prac-
to the negro boiler, till a less barbarous mode of concentrating cane-juice
ed for the present *naked teache*, or *sugar frying-pan.*

k sugars are such as contain an inferior proportion of carbon in their com-
s first deduced by me from my experiments on the ultimate analysis of vege-
imal bodies; an account of which was published in the Philosophical Trans-
he Royal Society for 1822. Since then, Dr. Prout has arrived at results
of my views. See Philosophical Transactions for 1827. Thus, he found
andy, and the best refined sugar, to contain 42·85 parts of carbon per cent.;
sugar-candy, 41·9 parts; East India raw sugar in a thoroughly dry state, but
ality, 40·88; manna sugar, well refined, 28·7; sugar from Narbonne honey,
ır from starch, 36·2. Hence, by *caramelizing* the sirup in the *teache*, not
crystallizable sugar blackened, but its faculty of crystallizing impaired, and
portion rendered weaker.

sirup containing much gluten and sugar, altered by lime, requires a higher
to enable it to granulate than a pure saccharine sirup; and therefore the
r, though a useful adjuvant, can by no means be regarded as a sure guide, in
the proper instant for *striking* the *teache.*

ial *curing-house* is a capacious building, of which the earthen floor is exca-
m the molasses reservoir. This is lined with sheet lead, boards, tarras, or
ive cement; its bottom slopes a little, and it is partially covered by an open
me of joist-work, on which the potting casks are set upright. These are
ty sugar hogsheads, without headings, having 8 or 10 holes bored in their
ough each of which the stalk of a plantain leaf is stuck, so as to protrude
6 or 8 inches below the level of the joists, and to rise above the top of the
act of transferring the crude concrete sugar from the crystallizers into these
s called potting. The bottom holes, and the spongy stalks stuck in them,
olasses to drain slowly downwards into the sunk cistern. In the common
cedure, sugar of average quality is kept from 3 to 4 weeks in the curing-
which is soft-grained and glutinous must remain 5 or 6 weeks. The curing-
d be close and warm, to favor the liquefaction and drainage of the viscid

0 millions of pounds of raw sugar, which used to be annually shipped by the
planters, only 96 millions were landed in France, according to the authority
constituting a loss by drainage in the ships of 20 per cent. The average
aste at present in the sugars of the British colonies cannot be estimated at
per cent., or altogether upwards of 27,000 tons! What a tremendous sacri-
erty!

ese few years a very considerable quantity of sugar has been imported into
in in the state of concentrated cane-juice, containing nearly half its weight
sugar, along with more or less molasses, according to the care taken in the
rations. I was at first apprehensive that the sirup might undergo some
he voyage; but among more than a hundred samples which I have analyzed
m-house, I have not perceived any traces of fermentation. Since sugar softens
at each successive solution, whatever portion of the crop may be destined
er, should upon no account be granulated in the colonies; but should be
in the state of a rich cane-sirup to Europe, transferred at once into the
cistern, subjected there to the reaction of bone black, and passed through
r through layers of the coarsely ground black, previously to its final concen-
e vacuum pan. Were this means generally adopted, I am convinced that 30
uld be added to the amount of home-made sugar loaves corresponding to a
ity of average cane-juice; while 30 per cent. would be taken from the
olasses. The saccharine matter now lost by drainage from the hogsheads in
nounting to from 10 to 15 per cent., would also be saved. The produce of
uld, on this plan, require less labor in the colonies, and might be exported 5
earlier than at present, because the period of drainage in the curing-house
ared.

ot appear that our sugar colonists have availed themselves of the proper
thod of counteracting that incipient fermentation of the cane-juice, which
upervenes, and proves so injurious to their products. It is known that grape-
impregnated with sulphurous acid, by running it slowly into a cask in
sulphur matches have been burned, will keep without alteration for a year;
so *muted*, is boiled into a sirup within a week or ten days, it retains no
odor. A very slight muting would suffice for the most fermentable cane-

juice; and it could be easily given, by burning a sulphur match within the cistern immediately before charging it from the mill. The cane-juice should, in this case, be heated in the clarifier, so as to expel the sulphurous acid, before adding the temper lime; for otherwise a little calcareous sulphite might be introduced into the sugar. Thus the acescence so prejudicial to the saccharine granulation would be certainly prevented.

An ACCOUNT of SUGAR Imported into the United Kingdom during the years ending 5th January, 1837, and 5th January, 1838.

	Quantities imported.						Quantities entered for Home Consumption.						Gross amount of Duty received.	
	1837.			1838.			1837.			1838.			1837.	1838.
Sugar, unrefined; viz.—of the British possessions in America,	Cwt. 3,600,516	qr. 3	lb. 2	Cwt. 3,304,092	qr. 2	lb. 2	Cwt. 3 296,641	qr. 1	lb. 19	Cwt. 3,562,703	qr. 1	lb. 24	£. 3,956,879	£. [illegible]
Of Mauritius,	497,303	0	8	537,054	1	21	518,228	0	5	522,348	3	11	621,596	[illegible]
East India British possessions,	152,229	1	13	296,677	2	12	110,236	2	0	270,146	1	2	176,376	[illegible]
East India Foreign possessions,	71.464	2	0	77,090	0	18	20	3	18	3	3	11	66	12
Other sorts	327,647	1	12	266,559	2	24	31	1	6	37	3	10	41	5
Total,	4,649,161	0	7	4,481,474	1	21	3,925,140	0	20	4,355,240	1	2	4,754,958	5,278,117

An ACCOUNT of SUGAR Exported in the year ending 5th January, 1838, compared with the Exports of the preceding Year.

	1837.			1838.		
	Cwts.	qrs.	lbs.	Cwts.	qrs.	lbs.
Sugar, of the British possessions in America	8,774	1	15	9,267	0	21
Mauritius - - - - - -	2,687	3	14	3,065	0	19
East India, of British possessions	22,290	3	16	13,283	0	22
Foreign do.	52,384	0	4	68,252	2	18
Other sorts - - - - - -	191,961	0	20	354,513	1	23

Sirup intended for forming clayed sugar must be somewhat more concentrated in the teache, and run off into a copper cooler, capable of receiving three or four successive skippings. Here it is stirred to ensure uniformity of product, and is then transferred by ladles into conical moulds, or *formes*, made of coarse pottery, having a small orifice at the apex, which is stopped with a plug of wood wrapped in a leaf of maize. These pots are arranged with the base upwards. As their capacity, when largest, is greatly less than that of the smallest potting-casks, and as the process lasts several weeks, the claying-house requires to have very considerable dimensions. Whenever the sirup is properly granulated, which happens usually in about 18 or 20 hours, the plugs are removed from the apices of the cones, and each is set on an earthen pot to receive the drainings. At the end of 24 hours, the cones are transferred over empty pots, and the molasses contained in the former ones is either sent to the fermenting-house or sold. The claying now begins, which consists in applying to the smoothed surface of the sugar at the base of the cone, a plaster of argillaceous earth, or tolerably tenacious loam in a pasty state. The water diffused among the clay escapes from it by slow infiltration, and descending with like slowness through the body of the sugar, carries along with it the residuary viscid sirup which is more readily soluble than the granulated particles. Whenever the first magma of clay has become dry, it is replaced by a second; and this occasionally in its turn by a third, whereby the sugar cone gets tolerably white and clean. It is then dried in a stove, cut transversely into *frusta*, crushed into a coarse powder, on wooden trays, and shipped off for Europe. Clayed sugars are sorted into different shades of color, according to the part of the cone from which they were cut; under the denomination in French commerce of *premier*, *second*, *troisième*, *petit*, *commun*, and *tête*; the last or the tip being an indifferent article. The clayed sugar of Cuba is called Havana sugar, from the name of the shipping port.

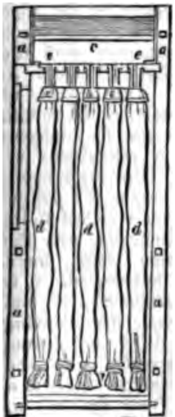
Clayed sugar can be made only from the ripest cane-juice, for that which contains much gluten would be apt to get too much burned by the ordinary process of boiling, to bear the claying operation. The sirups that run off from the second, third, and fourth applications of the clay-paste, are concentrated afresh in a small building apart, called the refinery, and yield tolerable sugars. Their drainings go to the molasses cistern. The cones remain for 20 days in the claying-house, before the sugar is taken out of them.

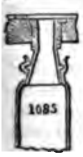
Claying is seldom had recourse to in the British plantations, on account of the increase of labor, and diminution of weight in the produce, for which the improvement in quality yields no adequate compensation. Such, however, was the esteem in which the French consumers held clayed sugar, that it was prepared in 400 plantations of St. Domingo alone.

SUGAR REFINING.

Raw, or muscovado sugar, as imported from the colonies, is contaminated more or less with gluten, lime, but particularly *caramel*, which give its grains a yellow brown tint, an empyreumatic odor, and a soft clammy feel in the hand. If such sugar be dissolved in water, and the sirup be evaporated by a gentle heat, it will afford a sugar of still inferior quality and appearance. This rapid deterioration is in some measure owing to the injurious operation of a prolonged heat upon the crystalline structure, but chiefly to the chemical reaction of the glutinous ferment and lime upon the sugar. The first care of the refiner should therefore be the immediate abstraction of these noxious alteratives, which he effects by the process called *meltings*; that is, mixing up the sugar in a pan with hot water or steam into a pap, and transferring this pap into large sugar-moulds. Whenever these become cool, their points are unplugged, and they are set to drain for a few days in a warm apartment. Sugar thus cleansed is well prepared for the next refining process; which consists in putting it into a large square copper cistern along with some lime-water, (a little bullock's blood,) and from 5 to 20 per cent. of bone black, and blowing it up with steam; or, in other words, injecting steam through the mixture from numerous orifices in copper pipes laid along the bottom and sides of the vessel. Under the influence of the heat and agitation thus occasioned, the saccharine matter is perfectly dissolved and incorporated with the albumen of the blood and the bone black. Instead of the blood, many refiners employ a mixture of gelatinous alumina and gypsum, called *finings*, prepared by adding a solution of alum to a body of lime-water, collecting, washing, and draining the precipitate upon a filter. Other refiners use both the blood and finings, with advantage. Bone black is now very frequently employed by the sugar-refiner, not in a fine meal, but in a granular state, like corned gunpowder, for the purpose of decoloring his sirups; in which case, he places it in a box, in a stratum 8 or 10 inches thick, and makes the sirup percolate downwards through it, into a cistern placed beneath. By this means it is deprived of color, and forms the *clairce* of the French refiner. When the blowing up cistern is charged with sugar, finely ground bone black, and blood, the mixture must be passed through a proper system of filters. That now most in use is the creased bag filter, represented in *figs*. 1084 1085, 1086.

1084

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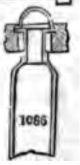

1086

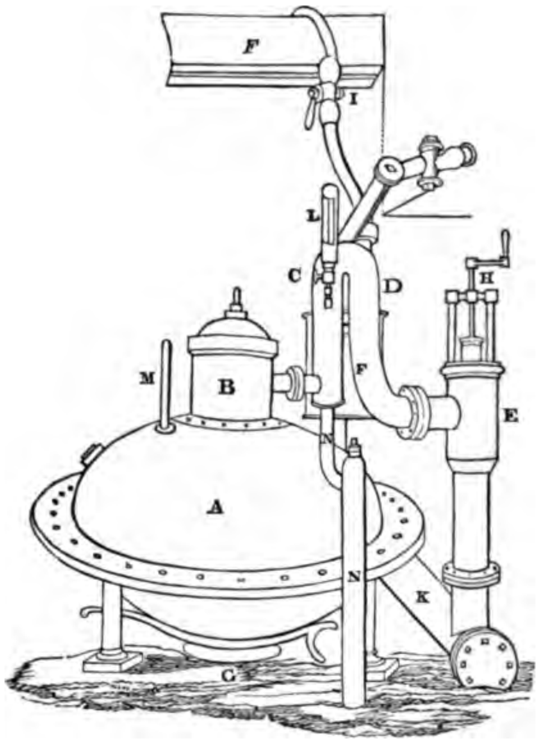
The apparatus consists of an upright square wooden case *a*, *a*, about 6 or 8 feet high, furnished with a door of admission to arrange the interior objects; beneath is a cistern with an educting-pipe for receiving and carrying off the filtered liquor; and above the case is another cistern *e*, which, like the rest, is lined with tinned sheet copper. Into the upper cistern, the sirup mixed with animal charcoal is introduced, and passes thence into the mouths *e*, *e*, of the several filters *d*, *d*. These consist each of a bag of thick tweeled cotton cloth, about 12 or 15 inches in diameter, and 6 or 8 feet long, which is inserted into a narrow bottomless bag of canvass, about 5 inches in diameter, for the purpose of folding the filter-bag up into a small space, and thus enabling a great extent of filtering surfaces to be compressed into one box. The orifice of each compound bag is tied round a conical brass mouth-piece or nozzle *e*, which screws tight into a corresponding opening in the copper bottom of the upper cistern. From 40 to 60 bags are mounted in each filter case. The liquor which first passes is generally tinged a little with the bone black, and must be pumped back into the upper cistern, for refiltration. In cold weather the interior of the case may be kept warm by a proper distribution of steam-pipes. *Fig.* 1085 shows one mode of forming the funnel-shaped nozzles of the bags, in which they are fixed by a bayonet catch. *Fig.* 1086 shows the same made fast by means of a screwed cap, which is more secure.

The next process in sugar-refining is the evaporation of the clarified sirup to the granulating or crystallizing pitch. The more rapidly this is effected, and with the less scorching injury from fire, the better and greater is the product in sugar-loaves. No apparatus answers the refiner's double purpose of safety and expedition so well as the acuum-pan of Howard.

Fig. 1087 shows the structure of a single vacuum-pan. The horizontal diameter of the copper spheroid A, is not less than 5 feet; the depth of the under hemisphere is at least 18 inches from the level of the plane; and the height of the dome-cover is 2 feet. The two hemispheres (of which the inferior one is double, or has a steam-jacket) are put together by bolts and screws, with packing between the flanges to preserve the joints tight against atmospheric pressure. The jacket of the lower hemisphere forms the case of the steam, which communicates heat to the sirup enclosed in the inner hemisphere. In general, the pans contain, when filled to the flange, 100 gallons of sirup, and yield about 11 cwts. of granulated sugar, at every charge.

A, represents the vacuum spheroid; B, the neck with the lid. From the side of B, a pipe passes into the lower extremity of the bent pipe C, D, which terminates in the vertical pipe E, connected with the vacuum main-pipe K, proceeding horizontally from the air-pump (not shown in the figure). At the top of E, a valve, moveable by a screw H, is placed for establishing or cutting off the connexion with the air-pump at pleasure. Behind F, is the measure cistern, from which the successive charges are admitted into the pan. This measure is filled with the clear sirup, by opening the stopcock I, on the pipe under the ceiling, which communicates with the filter-cistern placed above. G is the valve or plug-hole, at the bottom of the pan, for discharging the granulating sirup. This plug is opened by means of a powerful lever attached to it; the connexion with the air-pump being previously intercepted. L, is the barometer, or manometer, for showing the state of the vacuum corresponding to the temperature. N, N, is a cistern-pipe for receiving any little sirup which may accidentally boil over the neck B. Its contents are let off by a stopcock at its bottom from time to time. M shows the place of the *proof-stick*, an ingenious brass rod for taking out a sample of sirup without admitting air. See *infrà*.

1087



The charging-cistern contains about 20 gallons. This quantity of sirup being first admitted, and brought to a certain pitch of concentration, a second measure is introduced, the inspissation of which is supposed by some refiners to cause an agglomeration of saccharine matter round the first crystalline particles. The repetition of this process for two or three times is imagined to produce the large brilliant grain of vacuum-pan sugar. This hypothesis is more specious than sound, because the granulating sirup discharged from the pan is subjected to a heat of 180° or 190° in the subjacent steam-cased receiver, whereby the granulations are again reduced to a very small size. Into this receiver, two or three skippings or discharges of the pan are admitted in succession, and the whole are diligently mixed and agitated by a stirring oar. It is by this process that the granulating tendency is promoted and determined. From this receiver (absurdly enough called a cooler) the moulds are filled in the usual way, by means of copper basins or large ladles.

The case of the under hemisphere of the vacuum-pan is filled with steam, generated under a pressure of four or five pounds on the square inch; the heat of which causes the interior sirup to boil rapidly while the air-pump is kept in action. A small escape-pipe for waste steam must be placed at the opposite side of the case or jacket, to ensure its equal distribution; as also a stopcock below, to let off the water of condensation. The pans are mounted on iron feet, or short pillars, which insulate them from the floor, and allow their whole surface to be inspected, and any flaw to be repaired. The air-pump usually stands in a cold-water cistern, to favor the condensation of the aqueous vapor, which it draws out of the pans; and it is kept in constant action by the steam-engine, being attached to the working-beam of its piston.

Fig. 1088 exhibits the general arrangement of the vacuum-pans, and their subsidiary apparatus. Here are shown, on the ground floor, the heaters *e*, *e*, (miscalled coolers), into which the concentrated sirup is let down. These heaters are made of copper, in one piece, surrounded with a cast-iron jacket, bolted at the flange or brim to it. Each pan contains, when full, about 350 gallons, equivalent to nearly 35 cwts. of crystallized sugar. They are furnished with steam-cocks and waste steam-pipes. Under the level of the spheroids *d*, *d*, the horizontal main-pipe is seen, for supplying the cases with steam. In the face of each pan, above the line *b*, *b*, the handle of the proof-stick appears, like that of a stopcock. The distribution of the measure cisterns, and some other parts of the pans, is slightly varied in this representation from the former. From the bottom of the liquor cisterns c, c, pipes descend to the charging measures *a*, *a*, below. The cisterns c, c, are made of copper, and contain each about 400 gallons. Six tons of refined sugar can be turned out daily in a three-pan house.

1088

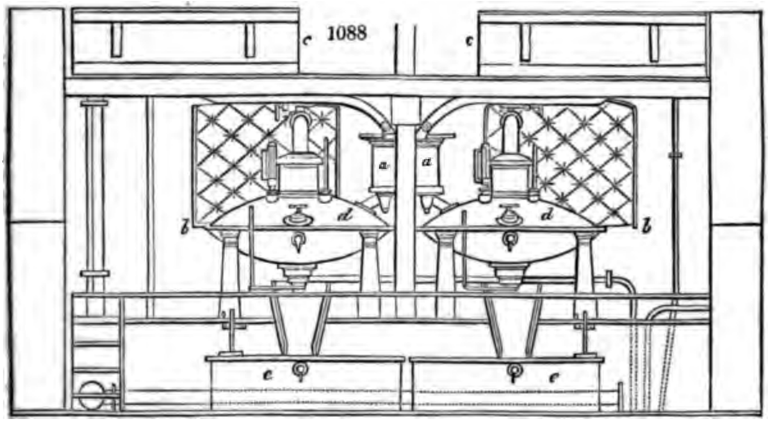
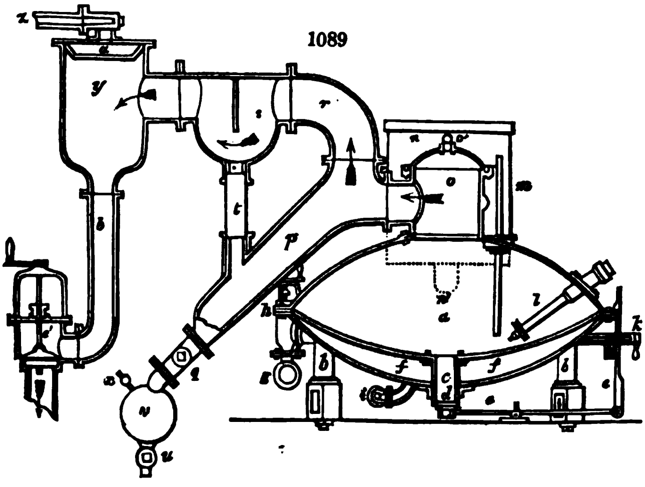


Fig. 1089 represents in section another form of the vacuum-pan. *a* is the spheroidal copper vessel, supported by four iron columns *b*, *b*. It may be discharged by means of the pipe *c*, which is secured with a conical valve *d*. This may be opened or shut, by acting on the lever *e*. The lower of the two hemispheres of which the pan is composed

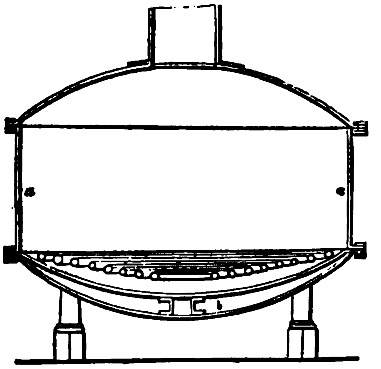
1089



is double, and the interstitial space *f*, *f*, is filled with steam by the pipe *g*, as the heating and evaporating agent. *h*, is the steam valve; *i*, the pipe for the efflux of the condensed water. *k*, a tube for the escape of the air at the commencement of the operation. *l*, is an apparatus inserted air-tight into the cover of the vacuum-pan, and which dips down into the sirup; serving to take out a sample of it, without allowing air to enter, and hence called the proof-stick. The construction of this instrument is exhibited in *figs.* 1091, 1092, 1093, 1094, 1095, which will be presently explained. *m*, is the thermometer, which is also plunged into the sugar; behind it, is the barometer. *n*, is the charger or gauge-vessel, filled with the filtered sirup, which it discharges by the pipe *n'*. *o*, is the cover or capital of the vacuum-pan. *o'*, is a safety-valve, through which the air may be admitted, after the completion of the process. *p*, is a bent pipe, slanting downwards, with a stopcock *q*, at its end, to receive the superfluous sirup. The vapor, which is disengaged from the sirup during its concentration, is extracted from the top of the pan into the pipe *r*, passes from this into the vessel *s*, which is divided by a plate of copper into two compartments. The sirup forced over accidentally in the ebullition, goes into the vessel *s*, and passes by the glass tube *t*, into the pipe *p*. The glass tube serves to show the quantity of the sirup that has boiled over, so that it may be drawn off when necessary. For this purpose, the stopcock *u*, of the vessel *v*, must be closed, and *q* must be opened, in order to fill *v*, while the air contained in it escapes into the pan. The stopcock *q*, being then shut, and *u*, with the little air-cock *x*, opened, the sirup will flow into the large receiver placed beneath it, commonly but erroneously called a cooler; because it is a double copper basin, with steam in the interstitial space. The hot steam rushes from *s*, into the cast-iron vessel *y*, where it is condensed. *z*, is a pipe for introducing the water of condensation through the copper rose *a'*. The condensed water flows through the pipe *b'*, and the valve *e'*, to the air-pump, which receives motion from the shaft of the steam-engine.

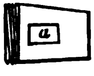
The vacuum-pan was originally heated solely by the admission of steam between the double bottom; but of late years the heat has been also applied to the sirup through several coils of pipe placed within the pan, filled with steam at a temperature many degrees above 212° F., sometimes so high as 250°. By this double application of heat, the evaporating power of a pan has been vastly increased. The latest made pans have a considerably flat bottom, *fig.* 1090; a spiral pipe, laid close upon it; and between the under hemisphere and the upper one, there is a space *a*, *a*, 2½ feet high, to give the sirup room for frothing up without boiling over. The space *b*, of the bottom receives steam of common pressure, and the spiral tubes, of high pressure. A pan like this is now making for a house in London, which is to work off 16 tons of sugar-loaves daily.

1090

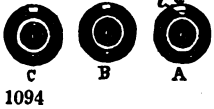


The proof-stick, *fig.* 1095, consists of a cylindrical rod, capable of being screwed air-tight into the pan in an oblique direction downwards. The upper or exterior end is open; the under, which dips into the sirup, is closed, and has on one side a slit *a* (*figs.* 1091, 1092) or notch, about ⅓ inch wide. In this external tube, there is another shorter tube *b*, capable of moving round in it, through an arc of 180°. An opening upon the under end *c*, corresponds with the slit in the outer tube, so that both may be made to coincide, *fig.* 1091, A. A wooden plug *d*, is put in the interior tube, but so as not to shut it entirely. Upon the upper end there is a projection or pin, which catches in a slit of the inner tube, by which this may be turned round at pleasure. In the lower end of the plug there is a hole *e*, which can be placed in communication with the lateral openings in both tubes. Hence it is possible, when the plug and the inner tube are brought into the proper position, A, *fig.* 1091, to fill the cavity of the wooden rod with the sirup, and to take it out without

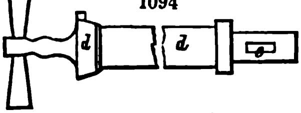
1092



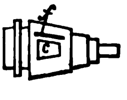
1091



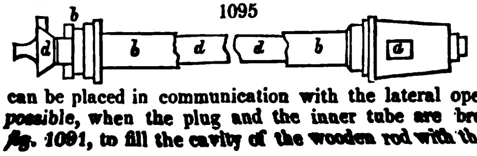
1094



1093



1095



allowing any air to enter. In order to facilitate the turning of the inner tube within the outer, there is a groove in the under part, into which a little grease may be introduced.

Whenever a proof has been taken, the wooden plug must be placed in reference to the inner tube, as shown in *fig.* 1091, C, and then be turned into the position A; when the cavity of the plug will again be filled with sirup. C must be now turned back to the former position, whereby all intercourse with the vacuum-pan is cut off; the plug being drawn out a little, and placed out of communication with the inner tube. The plug is then turned into the position B, drawn out, and the proof examined by the fingers.

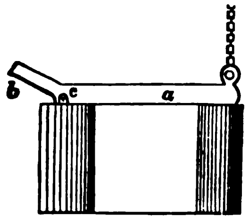
TABLE showing the boiling point of sirup, at the corresponding atmospheric pressure within the vacuum-pan:—

Height of the mercury (inches) in one leg of the syphon, above that in the other—	0·74	0·86	1·01	1·17	1·36	1·57	1·80	2·05	2·36	2·72	3·10	3·52	4·00.
Boiling point, Fahr.—	115°	120°	125°	130°	135°	140°	145°	150°	155°	160°	165°	170°	175°.

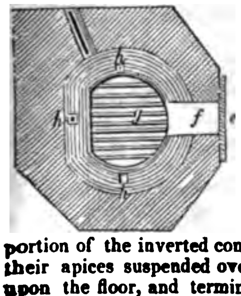
The large double steam-basin, which receives several successive skippings of the concentrated granulating sirup, serves to heat it from the temperature of 160° or 170°, at which it leaves the vacuum-pan, up to 200° or thereby, before it is filled out into the moulds; for were it introduced in the cooler state, it would not concrete into sufficiently compact loaves.

The following apparatus is used in many French sugar-houses, for concentrating sirups, called the *swing pan*, or *chaudière à bascule*. It is represented in *fig.* 1096, in elevation, and in *fig.* 1097, in ground plan. *a*, is the pan; *b*, its spout; *c*, the axis or pivot round which it swings, so as to empty itself, when raised behind by the chain *d*; *e*, is the furnace door; *f*, the passage to the fireplace and grate *g*; *h*, *h*, *h*, side flues for conducting the smoke into the chimney.

1096



1097



The duly clarified, concentrated, granulated, and reheated sirup, is transferred, by means of copper basins, from the coolers into conical moulds, made either of brown and somewhat porous earthenware, or of sheet iron, strongly painted. The sizes of the moulds vary, from a capacity of 10 pound *loaves*, to that of 56 pound *bastards*—a kind of soft brown sugar obtained by the concentration of the inferior sirups. These moulds have the orifices at their tips closed with bits of twisted paper, and are set up in rows close to each other, in an airy apartment adjoining the coolers. Here they are left several hours, commonly the whole night, after being filled, till their contents become solid, and they are lifted next morning into an upper floor, kept at a temperature of about 80° by means of steam pipes, and placed each over a pot to receive the sirup drainings—the paper plug being first removed, and a steel wire, called a piercer, being thrust up to clear away any concretion from the tip. Instead of setting the lower portion of the inverted cones in pots, some refiners arrange them in wooden racks, with their apices suspended over longitudinal gutters of lead or zinc, laid with a slight slope upon the floor, and terminating in a sunk cistern. The sirup which flows off spontaneously is called green sirup. It is kept separate. In the course of two or three days, when the drainage is nearly complete, some finely clarified sirup, made from loaf sugar, called *liquor* by the refiners, is poured to the depth of about an inch upon the base of each cone, the surface having been previously rendered level and solid by an iron tool, called a bottoming trowel. The liquor, in percolating downwards, being already a saturated sirup, can dissolve none of the crystalline sugar, but only the colored molassy matter; whereby, at each successive liquoring, the loaf becomes whiter, from the base to the apex. A few moulds, taken promiscuously, are emptied from time to time, to inspect the progress of the blanching operation; and when the loaves appear to have acquired as much *color*, according to the language of refiners, as is wanted for the particular market, they are removed from the moulds, turned on a lathe at the tips, if necessary, set for a short time upon their bases, to diffuse their moisture equally through them, and then transferred into a stove heated to 130° or 140° by steam pipes, where they are allowed to remain for two or three days, till they be baked thoroughly dry. They are then taken out of the stove, and put up in blue paper for sale.

In the above description of sugar-refining, I have said nothing of the process of claying the loaves, because it is now nearly obsolete, and abandoned in all well-appointed sugar-houses. Those of my readers who desire to become acquainted with sugar-refining upon the old plan, may consult my Report made upon the subject to the Honorable House of Commons in July, 1833; where they will find every step detailed, and the numerical results stated with minute accuracy. The experiments subservient to that official report were instituted purposely to determine the average yield or product, in double and single refined loaves, lumps, bastards and treacle, which different kinds of sugar would afford per cwt., when refined by decoloring with not more than 5 per cent. of bone black, boiling in an open pan, and clearing the loaves with clay-pap.

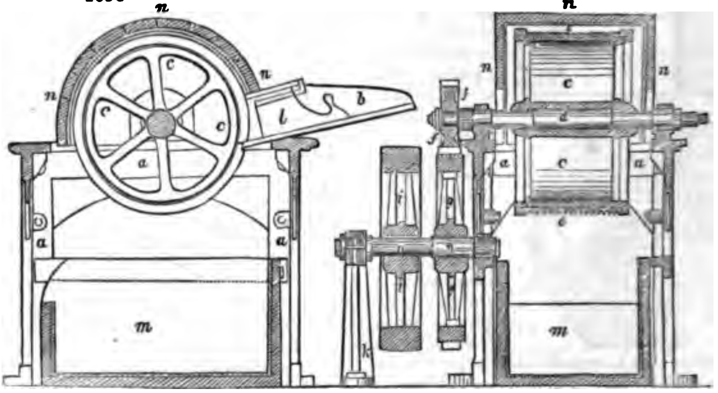
BEET-ROOT SUGAR.

The physical characters which serve to show that a beet-root is of good quality, are its being firm, brittle, emitting a creaking noise when cut, and being perfectly sound within; the degree of sweetness is also a good indication. The 45th degree of latitude appears to be the southern limit of the successful growth of beet in reference to the extraction of sugar.

Extraction of Sugar from the Beet. — The first manipulations to which the beets are exposed, are intended to clear them from the adhering earth and stones, as well as the fibrous roots and portions of the neck. It is desirable to expose the roots, after this operation, to the action of a cylinder washing-machine.

The parenchyma of the beet is a spongy mass, whose cells are filled with juice. The cellular tissue itself, which forms usually only a twentieth or twenty-fifth of the whole weight, consists of ligneous fibre. Compression alone, however powerful, is inadequate to force out all the liquor which this tissue contains. To effect this object, the roots must be subjected to the action of an instrument which will tear and open up the greatest possible number of these cells. Experiments have, indeed, proved, that by the most considerable pressure, not more than 40 or 50 per cent. in juice from the beet can be obtained; whilst the pulp procured by the action of a grater produces from 75 to 80 per cent.

1098 1099



The beet-root rasp of Moulfarine is represented in *figs.* 1098, 1099. *a*, *a*, is the frame-work of the machine; *b*, the feed-plate, made of cast iron, divided by a ridge into two parts; *c*, the hollow drum; *d*, its shaft, upon either side of whose periphery nuts are screwed for securing the saw blades *e*, *e*, which are packed tight against each other by means of laths of wood; *f*, is a pinion upon the shaft of the drum, into which the wheel *g* works, and which is keyed upon the shaft *h*; *i*, is the driving rigger; *k*, pillar of support; *l*, blocks of wood, with which the workman pushes the beet-roots against the revolving-rasp; *m*, the chest for receiving the beet-pap; *n*, the wooden cover of the drum, lined with sheet iron. The drum should make 500 or 600 turns in the minute.

A few years ago, M. Dombasle introduced a process of extracting the juice from the beet without either rasping or hydraulic pressure. The beets were cut into thin slices, by a proper rotatory blade-machine; these slices were put into a macerating cistern, with about their own bulk of water, at a temperature of 212° F. After half an hour's maceration, the liquor was said to have a density of 2° B., when it was run off into a second similar cistern, upon other beet-roots; from the second it was let into a third, and so on to a fifth; by which time, its density having risen to 5½°, it was ready for the process of defecation. Juice procured in this way is transparent, and requires little lime for its purification; but it is apt to ferment, or to have its granulating power impaired by the watery dilution. The process has been accordingly abandoned in most establishments.

I have seen the following operations successfully executed in a beet-root factory near Lille, and have since verified their propriety in my own laboratory upon white beets, grown near Mitcham in Surrey. My product was nearly 5 per cent.; it was very fair, and large grained, like the vacuum-pan sugar of Demerara, but without its clamminess.

The roots were washed by a rotatory movement upon a grating made like an Archimedes' screw, formed round the axis of a squirrel-cage cylinder, which was laid horizontally beneath the surface of water in an oblong trough. It was turned by hand rapidly, with the intervention of a toothed wheel and pinion. The roots, after being sufficiently agitated in the water, were tossed out by the rotation at the end of the cylinder furthest from the winch. They were next hoisted in a basket up through a trap-hole into the floor above, by means of a cord and pulley moved by mechanical power; a six-horse steam engine, upon Woolfe's expansive principle, being employed to do all the heavy work. They were here subjected to the mechanical grater (*rape mécanique*), see *figs*. 1098, 1099, which had, upon its sloping feed-table, two square holes for receiving at least two beets at a time, which were pushed forwards by a square block of wood held in the workman's hand by means of a strap. The rasp was a drum, having rows of straight saws placed half an inch apart round its periphery, *parallel to the axis*, with teeth projecting about ⅛ of an inch. The space between each pair of saws was filled with a wedge of wood. The steel slips, or saw plates, were half an inch broad, twelve inches long, and serrated on both their longitudinal edges, so that when the one line of teeth was blunted, the other could be turned out. The drum made 750 turns per minute.

The pulp from the rasp fell into a flat trough placed beneath, whence it was shovelled into small bags. Each bag had its mouth folded over, was laid upon a wicker plate, and spread flat with a rolling-pin. The bags and hurdles were then piled in the hydraulic press. There were three presses, of which the two allotted to the first pressure were charged alternately, and the third was reserved for a final and more durable pressure of the *marc*. See PRESS, HYDRAULIC, and STEARINE PRESS.

The juice flowed over the edges of the wicker plates, and fell into the sill-plate of the press, which was furnished with upright borders, like a tray, through whose front side a pipe issued, that terminated in a leathern hose, for conducting the juice into an elevated cistern in the boiling-house. Here one pound of slaked lime was mixed with every four hectolitres (about 88 gallons imp.) of juice. The mixture was made to boil for a little while in a round pan alongside, whence it was decanted into oblong flat filters, of blanket stuff. The filtered liquor, which had in general a spec. gravity of 15° Baumé (about double that of the fresh juice), was now briskly concentrated by boiling, in an oblong pan, till it acquired the density of 28° B. The fire being damped with raw coal, the sirup was run off rapidly by a stopcock into a large basin with a swing handle, and immediately replaced by fresh defecated liquor. The basin was carried by two men to the opposite side of the boiling-house, and emptied into a cistern set on a high platform, whose horizontal discharge-pipe was provided with a series (five) of stopcocks, placed respectively over five copper chests (inverted truncated pyramids), containing a thick bed of granular bone black, covered with a perforated copper plate. The hot sirup thus filtered had a pale straw-color, and was subsequently evaporated in swing pans, *figs*. 1096, 1097, over a brisk fire, in quantities equivalent to half a cwt. of sugar, or four hectolitres of average juice.

MAPLE SUGAR.

The manufacture of sugar from the juice of a species of maple tree, which grows spontaneously in many of the uncultivated parts of North America, appears to have been first attempted about 1752, by some of the farmers of New England, as a branch of rural economy.

The sugar maple, the *Acer saccharinum* of Linnæus, thrives especially in the States of New York and Pennsylvania, and yields a larger proportion of sugar than that which grows upon the Ohio. It is found sometimes in thickets which cover five or six acres of land; but it is more usually interspersed among other trees. They are supposed to arrive at perfection in forty years.

The extraction of maple sugar is a great resource to the inhabitants of districts far removed from the sea; and the process is very simple. After selecting a spot among surrounding maple trees, a shed is erected, called the *sugar-camp*, to protect the boilers and the operators from the vicissitudes of the weather. One or more augers, three fourths of an inch in diameter; small troughs for receiving the sap; tubes of elder or sumach, 8 or 10 inches long, laid open through two thirds of their length, and corresponding in size to the auger-bits; pails for emptying the troughs, and carrying the sap to the camp; boilers capable of holding 15 or 16 gallons; moulds for receiving the sirup inspissated to the proper consistence for concreting into a loaf of sugar; and, lastly, hatchets to cut and cleave the fuel, are the principal utensils requisite for this manufacture. The whole of February and beginning of March are the sugar season.

The trees are bored obliquely from below upwards, at 18 or 20 inches above the ground, with two holes 4 or 5 inches asunder. Care must be taken that the auger penetrates no more than half an inch into the alburnum, or white bark; as experience has proved that a greater discharge of sap takes place at this depth than at any other. It is also advisable to perforate in the south face of the trunk.

The trough, which contains from two to three gallons, and is made commonly of white pine, is set on the ground at the foot of each tree, to receive the sap which flows through the two tubes inserted into the holes made with the auger; it is collected together daily, and carried to the camp, where it is poured into casks, out of which the boilers are supplied. In every case, it ought to be boiled within the course of two or three days from flowing out of the tree, as it is liable to run quickly into fermentation, if the weather become mild. The evaporation is urged by an active fire, with careful skimming during the boiling; and the pot is continually replenished with more sap, till a large body has at length assumed a sirupy consistence. It is then allowed to cool, and passed through a woollen cloth, to free it from impurities.

The sirup is transferred into a boiler to three fourths of its capacity, and it is urged with a brisk fire, till it acquires the requisite consistence for being poured into the moulds or troughs prepared to receive it. This point is ascertained, as usual, by its exhibiting a granular aspect, when a few drops are drawn out into a thread between the finger and the thumb. If in the course of the last boiling, the liquor froth up considerably, a small bit of butter or fat is thrown into it. After the molasses have been drained from the concreted loaves, the sugar is not at all deliquescent, like equally brown sugar from the cane. Maple sugar is in taste equally agreeable with cane sugar, and it sweetens as well. When refined, it is equally fair with the loaf sugar of Europe.

The period during which the trees discharge their juices is limited to about six weeks. Towards the end of the flow, it is less abundant, less saccharine, and more difficult to be crystallized.

Quantity of Sugar brought into the Markets of the World, in the year 1838.

	Tons.		Tons.
British West Indies	160,000	Bourbon	20,000
Mauritias, 35,000; and British East Indies 20,000	55,000	Cuba	100,000
		Brazils	95,000
Java	36,000	From Beet-root, in France and Belgium	65,000
Manilla and Siam	30,000		
Dutch West Indies	25,000	United States	65,000
St. Thomas and St. Croix	7,000		
Martinique and Guadaloupe	80,000		738,000*

SUGAR OF LEAD, properly *Acetate of lead* (*Acetate de plomb; Sel de Saturne*, Fr.; *Essigsaures Bleioxyd*, *Bleizucker*, Germ.), is prepared by dissolving pure litharge, with heat, in strong vinegar, made of malt, wood, or wine, till the acid be saturated. A copper boiler, rendered negatively electrical by soldering a strap of lead within it, is the best adapted to this process on the great scale. 325 parts of finely ground and sifted oxyde of lead, require 575 parts of strong acetic acid, of spec. grav. 7° Baumé, for neutralization, and afford 960 parts of crystallized sugar of lead. The oxyde should be gradually sprinkled into the moderately hot vinegar, with constant stirring, to prevent adhesion to the bottom; and when the proper quantity is dissolved, the solution may be weakened with some of the washings of a preceding process, to dilute the acetate, after which the whole should be heated to the boiling point, and allowed to cool slowly, in order to settle. The limpid solution is to be drawn off by a syphon, concentrated by boiling to the density of 32° B., taking care that there be always a faint excess of acid, to prevent the possibility of any basic salt being formed, which would interfere with the formation of regular crystals. Should the concentrated liquor be colored, it may be whitened by filtration through granular bone black.

Stoneware vessels, with salt glaze, answer best for crystallizers. Their edges should be smeared with candle-grease, to prevent the salt creeping over them by *efflorescent vegetation*. The crystals are to be drained, and dried in a stove-room very slightly heated. It deserves remark, that linen, mats, wood, and paper, imbued with sugar of lead, and strongly dried, readily take fire, and burn away like tinder. When the mother waters cease to afford good crystals, they should be decomposed by carbonate of soda, or by lime skilfully applied, when a carbonate or an oxyde will be obtained, fit for treating with fresh vinegar. The supernatant acetate of soda may be employed for the extraction of pure acetic acid.

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* For this important table, I am indebted to James Cook, Esq., of Mincing-lane.

A main point in the preparation of sugar of lead, is to use a strong acid; otherwise much time and acid are wasted in concentrating the solution. This salt crystallizes in colorless, transparent, four and six sided prisms, from a moderately concentrated solution; but from a stronger solution, in small needles, which have a yellow cast if the acid has been slightly impure. It has no smell, a sweetish astringent metallic taste, a specific gravity of 2·345; it is permanent in the air at ordinary temperatures, but effloresces when heated to 95°, with the loss of its water of crystallization and some acid, falling into a powder, which passes, in the air, slowly into carbonate of lead. The crystals dissolve in 1½ times their weight of water at 60°, but in much less of boiling water, and in 8 parts of alcohol. The solution feebly reddens litmus paper, but has an alkaline reaction upon the colors of violets and turmeric. The constituents of the salt are, 58·71 oxyde of lead, 27·08 acetic acid, and 14·21 water, in 100.

Acetate of lead is much used in calico-printing. It is poisonous, and ought to be prepared and handled with attention to this circumstance.

There are two subacetates of lead; the first of which, the ter-subacetate, has three atoms of base to one of acid, and is the substance long known by the name of Goulard's extract. It may be obtained by digesting with heat a solution of the neutral acetate, upon pure litharge or massicot. The solution affords white crystalline scales, which do not taste so sweet as sugar of lead, dissolve in not less than 30 parts of water, are insoluble in alcohol, and have a decided alkaline reaction upon test paper. Carbonic acid, transmitted through the solution, precipitates the excess of the oxyde of lead, in the state of a carbonate, a process long ago prescribed by Thenard for making white-lead. This subacetate consists of 88·66 of oxyde, and 13·34 acid, in 100 parts. It is employed for making the orange sub-chromate of lead, as also sometimes in surgery.

A *sex-subacetate*, containing 6 atoms of base, may be obtained by adding ammonia in excess to a solution of the preceding salt, and washing the precipitate with dilute water of ammonia. A white powder is thus formed, that dissolves sparingly in cold water, but gives a solution in boiling water, from which white silky needles are deposited. It consists of 92·86 oxyde, and 7·14 acid.

SULPHATES, are saline compounds of sulphuric acid with oxydized bases. The minutest quantity of them present in any solution, may be detected by the precipitate, insoluble in nitric or muriatic acid, which they afford with nitrate or muriate of baryta. They are mostly insoluble in alcohol.

SULPHATE OF ALUMINA AND POTASSA, is alum.

SULPHATE OF AMMONIA, is a salt sometimes formed by saturating the ammonia liquor of the gas-works with sulphuric acid; and it is employed for making carbonate of ammonia. See AMMONIA and SAL AMMONIAC.

SULPHATE OF BARYTA, is the mineral called heavy-spar, which frequently forms the gangue or vein-stone of lead and other metallic oars.

SULPHATE OF COPPER, *Roman or Blue Vitriol* (*Vitriol de Chypre*, Fr.; *Kupfervitriol*, Germ.), is a salt composed of sulphuric acid and oxyde of copper, and may be formed by boiling the concentrated acid upon the metal, in an iron pot. It is, however, a natural product of many copper mines, from which it flows out in the form of a blue water, being the result of the infiltration of water over copper pyrites, which has become oxygenated by long exposure to the air in subterranean excavations. The liquid is concentrated by heat in copper vessels, then set aside to crystallize. The salt forms in oblique four-sided tables, of a fine blue color; has a spec. gravity of 2·104; an acerb, disagreeable, metallic taste; and, when swallowed, it causes violent vomiting. It becomes of a pale dirty blue, and effloresces slightly, on long exposure to the air; when moderately heated, it loses 36 per cent. of water, and falls into a white powder. It dissolves in 4 parts of water, at 60°, and in 2 of boiling water, but not in alcohol; the solution has an acid reaction upon litmus paper. When strongly ignited, the acid flies off, and the black oxyde of copper remains. The constituents of crystallized sulphate of copper are—oxyde, 31·80; acid, 32·14; and water, 36·06. Its chief employment in this country is in dyeing, and for preparing certain green pigments. See SCHEELE'S and SCHWEINFURTH GREEN. In France, the farmers sprinkle a weak solution of it upon their grains and seeds before sowing them, to prevent their being attacked by birds and insects.

SULPHATE OF IRON, *Green vitriol*, *Copperas* (*Couperose verte*, Fr.; *Eisen-vitriol*, *Schwefelsures Eisenoxydul*, Germ.), is a crystalline compound of sulphuric acid and protoxyde of iron; hence called, by chemists, the protosulphate; consisting of, 26·10 of base, 29·90 of acid, and 44·00 of water, in 100 parts; or of 1 prime equivalent of protoxyde, 36, + 1 of acid, 40, + 7 of water, 63, = 139. It may be prepared by dissolving iron to saturation in dilute sulphuric acid. evaporating the solution till a pellicle forms upon its surface, and setting it aside to crystallize. The copperas of commerce is made in a much cheaper way, by stratifying the pyrites found in the coal measures (*Vitriolkies* and *Strahlkies* of the Germans), upon a sloping puddled platform of stone, leaving the sulphuret exposed to the weather, till, by the absorption of oxygen, it effloresces, lixiviating with water the supersulphate of iron thus formed, saturating the excess of acid with plates of old iron, then evaporating and crystallizing. The other pyrites, which occurs often crystallized, called by the Germans *Schwefelkies* or *Eisenkies*, must be deprived of a part of its sulphur by calcination, before it acquires the property of absorbing oxygen from the atmosphere, and thereby passing from a bisulphuret into a bisulphate. Alum schist very commonly contains vitriolkies, and affords, after being roasted and weather-worn, a considerable quantity of copperas, which must be carefully separated by crystallization from the alum.

This liquor used formerly to be concentrated directly in leaden vessels; but the first stage of the operation is now carried on in stone canals of considerable length, vaulted over with bricks, into which the liquor is admitted, and subjected at the surface to the action of flame and heated air, from a furnace of the reverberatory kind, constructed at one end, and discharging its smoke by a high chimney raised at the other. See SODA MANUFACTURE. Into this oblong trough, resting on dense clay, and rendered tight in the joints by water-cement, old iron is mixed with the liquor, to neutralize the excess of acid generated from the pyrites, as also to correct the tendency to superoxydizement in copperas, which would injure the fine green color of the crystals. After due concentration and saturation in this surface evaporator, the solution is run off into leaden boilers, where it is brought to the proper density for affording regular crystals, which it does by slow cooling, in stone cisterns.

Copperas forms sea-green, transparent, rhomboidal prisms, which are without smell, but have an astringent, acerb, inky taste; they speedily become yellowish-brown in the air, by peroxydizement of the iron, and effloresce in a warm atmosphere: they dissolve in 1·43 parts of water at 60°, in 0·27 at 190°, and in their own water of crystallization at a higher heat. This salt is extensively used in dyeing black, especially hats, in making ink and Prussian blue, for reducing indigo in the blue vat, in the China blue dye, for making the German oil of vitriol, and in many chemical and medicinal preparations.

There is a persulphate and subpersulphate of iron, but they belong to the domain of chemistry. The first may be formed, either by dissolving with heat one part of red oxyde of iron (colcothar) in one and a half of concentrated sulphuric acid, or by adding some nitric acid to a boiling-hot solution of copperas. It forms with galls and logwood a very black ink, which is apt to become brown-black. When evaporated to dryness, it appears as a dirty white pulverulent substance, which is soluble in alcohol. It consists, in 100 parts, of 39·42 of red oxyde of iron, and 60·58 sulphuric acid.

Hydrated peroxyde of iron, prepared by precipitation with alkali from solution of the persulphate, is an excellent antidote against poisoning by arsenic. A French *perruquier*, who had swallowed two drachms of arsenious acid, was, after an interval of twenty minutes, treated with the oxyde precipitated from 6 ounces of that salt by caustic potash. It was diffused in 20 quarts of weak sirup, and administered in successive doses. After repeated vomiting and purging, the patient felt no more pain, and was pronounced by the physician to be quite convalescent.

In the copperas and alum works, a very large quantity of ochrey sediment is obtained; which is a peroxyde of iron, containing a little sulphuric acid and alumina. This deposite, calcined in reverberatory hearths, becomes of a bright-red color; and when ground and elutriated, in the same way as is described under *white lead*, forms a cheap pigment, in very considerable demand, called *English red*, in the French market.

Colcothar of Vitriol, and Crocus of Mars, are old names for red oxyde of iron. This brown-red powder is obtained in its purest state, by calcining dried sulphate of iron in a furnace till all its acid be expelled, and its base become peroxydized. It must be levigated, elutriated, and dried. This powder is employed extensively in the steel manufacture, for giving the finishing lustre to fine articles; it is used by silversmiths under the name of plate powder and *rouge;* and by the opticians for polishing the specula of reflecting telescopes. Much of the *crocus* in the market, is made, however, from the copperas and alum sediments, and is greatly inferior to the article prepared by the last process. The finest *rouge* is made by precipitating the oxyde with soda, then washing and calcining the powder.

An excellent powder for applying to razor-strops, is made by igniting together in a crucible equal parts of well-dried copperas and sea salt. The heat must be slowly raised and well regulated, otherwise the materials will boil over in a pasty state, and the product will be in a great measure lost. When well made, out of contact of air, it has the brilliant aspect of plumbago. It has a satiny feel, and is a true *fer oligiste*, similar in composition to the Elba iron ore. It requires to be ground and elutriated; after which it affords, on drying, an impalpable powder, that may be either rubbed on a strop of smooth buff leather, or mixed up with hog's-lard or tallow into a stiff cerate.

SULPHATE OF LIME. See Gypsum.

SULPHATE OF MAGNESIA, *Epsom Salt* (*Sel amer*, Fr.; *Bittersalz*, Germ.), exists in sea-water, as also in the waters of Saidschütz, Sedlitz, and Püllna; and in many saline springs, besides Epsom in Surrey, whence it has derived its trivial name, and from which it was first extracted, in the year 1695, and continued to be so, till modern chemistry pointed out cheaper and more abundant sources of this useful purgative salt. The sulphate of magnesia, occasionally found effloresced on the surface of minerals in crystalline filaments, was called *haarsalz* (hair salt) by the older writers. The bittern of the Scotch sea-salt works is muriate of magnesia, mixed with a little sulphate of magnesia and chloride of sodium. If the proper decomposing quantity (found by trial) of sulphate of soda be added to it, and the mixed solution be evaporated at the temperature of 122° F., chloride of sodium will form by double affinity, and fall down in cubical crystals; while the solution of sulphate of magnesia which remains, being evaporated to the proper point, will afford regular crystals in four-sided prisms with four-sided acuminations. Or, if bittern be treated in a retort with the equivalent quantity of sulphuric acid, the muriatic acid may be distilled off into a series of Woulfe's bottles, and the sulphate of magnesia, soda, and lime, will remain in the retort, from which mixture the sulphate of magnesia may be separated by filtration and crystallization.

Magnesian limestone being digested with as much muriatic acid as will dissolve out its lime only, will, after washing, afford, with the equivalent quantity of sulphuric acid, a pure sulphate of magnesia; and this is certainly the simplest and most profitable process for manufacturing this salt upon the great scale. Many prepare it directly, by digesting upon magnesian limestone the equivalent saturating quantity of dilute sulphuric acid. The sulphate of lime being separated by subsidence, the supernatant solution of sulphate of magnesia is evaporated and crystallized.

This salt is composed of, magnesia 16·72, sulphuric acid 32·39, and water 50·89. When free from muriate, it tends to effloresce in the air. It dissolves in four parts of water at 32°, in 3 parts at 60°, in 1·4 at 200°, and in its own water of crystallization at a higher heat.

SULPHATE OF MANGANESE is prepared on the great scale for the calico-printers, by exposing the peroxyde of the metal and pitcoal ground together, and made into a paste with sulphuric acid, to a heat of 400° F. On lixiviating the calcined mass, a solution of the salt is obtained, which is to be evaporated and crystallized. It forms pale amethyst-colored prisms, which have an astringent bitter taste, dissolve in 2¼ parts of water, and consist of, protoxyde of manganese 31·93, sulphuric acid 35·87, and water 32·20, in 100 parts.

SULPHATE OF MERCURY is a white salt which is used in making corrosive sublimate. See Mercury. The subsulphate, called *Turbith Mineral*, is a pale yellow pigment, and may be prepared by washing the white sulphated peroxyde with hot water, which resolves it into the soluble supersulphate, and the insoluble subsulphate, or *Turbith*. It is poisonous.

SULPHATE OF POTASSA is obtained by first igniting and then crystallizing the residuum of the distillation of nitric acid from nitre.

SULPHATE OF SODA is commonly called Glauber's salt, from the name of the chemist who first prepared it. It is obtained by igniting and then crystallizing the residuum of the distillation of muriatic acid from common salt. It crystallizes in channelled 6-sided prisms. See Soda Manufacture.

SULPHATE OF ZINC, called also *White Vitriol*, is commonly prepared in the Harz, by washing the calcined and effloresced sulphuret of zinc or blende, on the same principle as green and blue vitriol are obtained from the sulphurets of iron and copper. Pure sulphate of zinc may be made most readily by dissolving the metal in dilute sulphuric acid, evaporating and crystallizing the solution. It forms prismatic crystals, which have an astringent, disagreeable, metallic taste; they effloresce in a dry air, dissolve in 2·3 parts of water at 60°, and consist of—oxyde of zinc, 28·29; acid, 28·18; water, 43·53. Sulphate of zinc is used for preparing drying oils for varnishes, and in the reserve or resist pastes of the calico-printer.

SULPHITES are a class of salts, consisting of sulphurous acid, combined in equivalent proportions with the oxydized bases.

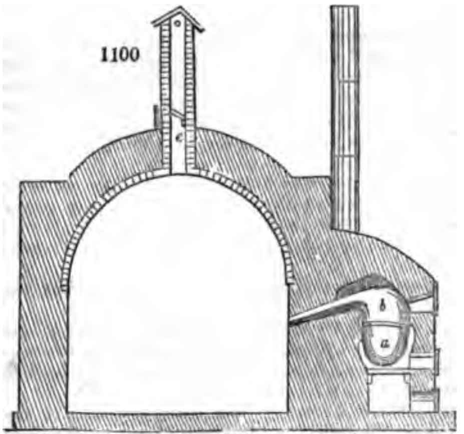
SULPHOSELS is the name given by Berzelius to a class of salts which may be prepared as follows:—1. Dissolve a salt consisting of an oxyde and an acid (an *oxysalt*) in a very small quantity of water, and pass through the solution a stream of sulphureted hydrogen, till the salt be entirely decomposed. In this operation, the *oxysalt* is transformed into a *sulphosalt*, by the sulphur of the compound gas; while its hydrogen forms water with the oxygen of the saline base. This process is applicable only to the metallic salts; and among these, not to the nitrates, carbonates, or phosphates. 2. Another method of preparing *sulphosalts* is, to add to a watery solution of sulphuret of potassium, an electro-negative metallic sulphuret, which will dissolve in the liquid till the sulphuret of potassium be saturated. This saline compound is to be employed to effect double decompositions with the oxysalts; that is, to convert the radical of another base, combined with an *oxacid*, into a sulphosalt. 3. If the electro-negative sulphuret be put in powder into a solution of the hydrosulphuret of potassa, it will dissolve and expel the sulphureted hydrogen with effervescence: just as carbonic acid is displaced by a stronger acid. For his other three methods of preparing *sulphosalts*, see his *Elements*, vol. iii. p. 336, Fr. translation.

SULPHUR, *Brimstone* (*Soufre*, Fr.; *Schwefel*, Germ.), is a simple combustible, solid, non-metallic, of a peculiar yellow color, very brittle, melting at the temperature of 226° Fahr., and possessing, after it has been fused, a specific gravity of 1·99. When held in a warm hand, a roll of sulphur emits a crackling sound, by the fracture of its interior parts; and when it is rubbed, it emits a peculiar well-known smell, and acquires at the same time negative electricity. When heated to the temperature of 560° F. it takes fire, burns away with a dull blue flame of a suffocating odor, and leaves no residuum. When more strongly heated, sulphur burns with a vivid white flame. It is not affected by air or water.

Sulphur is an abundant product of nature; existing sometimes pure or merely mixed, and at others in intimate chemical combination with oxygen, and various metals, forming sulphates and sulphurets. See ores of COPPER, IRON, LEAD, &c., under these metals.

Fig. 1100 represents one of the cast-iron retorts used at Marseilles for refining sulphur, wherein it is melted and converted into vapors, which are led into a large chamber for condensation. The body *a*, of the retort is an iron pot, 3 feet in diameter outside, 22 inches deep, half an inch thick, which weighs 14 cwts., and receives a charge of 8 cwts. of crude sulphur. The grate is 8 inches under its bottom, whence the flame rises and plays round its sides. A cast iron capital *b*, being luted to the pot, and covered with sand, the opening in front is shut with an iron plate. The chamber *d*, is 23 feet long, 11 feet wide, and 13 feet high, with walls 32 inches thick. In the roof, at each gable, valves or flap-doors, *e*, 10 inches square, are placed at the bottom of the chimney *c*. The cords for opening the valves are led down to the side of the furnace. The entrance to the chamber is shut with an iron door. In the wall opposite to the retorts, there are two apertures near the floor, for taking out the sulphur. Each of the two retorts belonging to a chamber is charged with 7½ or 8 cwts. of sulphur; but one is fired first, and with a gentle heat, lest the brimstone froth should overflow; but when the fumes begin to rise copiously, with a stronger flame. The distillation commences within an hour of kindling the fire, and is completed in six hours. Three hours after putting fire to the first retort, the second is in like manner set in operation.

1100



When the process of distillation is resumed, after having been some time suspended, explosions may be apprehended, from the presence of atmospherical air; to obviate the danger of which, the flap-doors must be opened every ten minutes; but they should remain closed during the setting of the retorts, and the reflux of sulphurous fumes or acid should be carried off by a draught-hood over the retorts. The distillation is carried on without interruption during the week, the charges being repeated four times in the day. By the third day, the chamber acquires such a degree of heat as to preserve the sulphur in a liquid state;, on the sixth, its temperature becoming nearly 300° F., gives the sulphur a dark hue, on which account the furnace is allowed to cool on the Sunday. The fittest distilling temperature is about 248°. The sulphur is drawn off through two iron pipes cast in the iron doors of the orifices on the side of the chamber opposite to the furnace. The iron stoppers being taken out of the mouths of the pipes, the sulphur is allowed to run along an iron spout placed over red-hot charcoal, into the appropriate wooden moulds.

Native sulphur in its pure state is solid, brittle, transparent, yellow, or yellow bordering on green, and of a glassy lustre when newly broken. It occurs frequently in crystalline masses, and sometimes in complete and regular crystals, which are all derivable from the rhomboidal octahedron. The fracture is usually conchoidal and shining. Its specific gravity is 2·072, exceeding somewhat the density of melted sulphur. It possesses a very considerable refractive power; and doubles the images of objects even across two parallel faces. Sulphur, crystallized by artificial means, presents a very remarkable phenomenon; for by varying the processes, crystals are obtained whose forms belong to two different systems of crystallization. The red tint, so common in the crystals of Sicily, and of volcanic districts, has been ascribed by some mineralogists to the presence of realgar, and by others to iron; but Stromeyer has found the sublimed orange-red sulphur of Vulcano, one of the Lipari islands, to result from a natural combination of sulphur and selenium.

It is extracted from the minerals containing it, at Solfatara, by the following process:—

Ten earthen pots, of about a yard in height, and four and a half gallons imperial in capacity, bulging in the middle, are ranged in a furnace called a gallery; five being set on the one side, and five on the other. These are so distributed in the body of the walls of the gallery, that their belly projects partly without, and partly within, while their top rises out of the vault of the roof. The pots are filled with lumps of the sulphur ore of the size of the fist; their tops are closed with earthenware lids, and from their shoulder proceeds a pipe of about two inches diameter, which bends down, and enters into another covered pot, with a hole in its bottom, standing over a tub filled with water. On applying heat to the gallery, the sulphur melts, volatilizes, and runs down in a liquid state into the tubs, where it congeals. When one operation is finished, the pots are re-charged, and the process is repeated.

In Saxony and Bohemia, the sulphurets of iron and copper are introduced into large earthenware pipes, which traverse a furnace-gallery; and the sulphur exhaled flows into pipes filled with cold water, on the outside of the furnace. 900 parts of sulphuret afford from 100 to 150 of sulphur, and a residuum of metallic protosulphuret. See Metallurgy and Copper.

Volcanic sulphur is purer than that extracted from pyrites; and as the latter is commonly mixed with arsenic, and some other metallic impregnations, sulphuric acid made of it would not answer for many purposes of the arts; though a tolerably good sulphuric acid may be made directly from the combustion of pyrites, instead of sulphur, in the lead chambers. The present high price of the Sicilian sulphur is a great encouragement to its extraction from pyrites. It is said that the common English brimstone, such as was extracted from the copper pyrites of the Parys mine of Anglesey, contained fully a fifteenth of residuum, insoluble in boiling oil of turpentine, which was chiefly orpiment; while the fine Sicilian sulphur, now imported in vast quantities by the manufacturers of oil of vitriol, contains not more than three per cent. of foreign matter, chiefly earthy, but not at all arsenical.

Sulphur has been known from the most remote antiquity. From its kindling at a moderate temperature, it is employed for readily procuring fire, and lighting by its flame other bodies not so combustible. At Paris, the preparation of sulphur matches constitutes a considerable branch of industry. The sulphurous acid formed by the combustion of sulphur in the atmospheric air, is employed to bleach woollen and silken goods, as also cotton stockings; to disinfect vitiated air, though it is inferior in power to nitric acid vapor and chlorine; to kill mites, moths, and other destructive insects in collections of zoology; and to counteract too rapid fermentation in wine-vats, &c. As the same acid gas has the property of suddenly extinguishing flame, sulphur has been thrown into a chimney on fire, with the best effect; a handful of it being sometimes sufficient. Sulphur is also employed for cementing iron bars in stone; for taking impressions from seals and cameos, for which purpose it is kept previously melted for some time, to give the casts an appearance of bronze. Its principal uses, however, are for the manufactures of vermilion, or cinnabar, gunpowder, and sulphuric acid.

See Metallurgy, page 829, for the description of Gahn's furnace for extracting sulphur from pyrites.

Pyrites as a bi-sulphuret, consisting of 45·5 parts of iron, and 54·5 of sulphur, may, by proper chemical means, be made to give off one half of its sulphur, or about 27 per cent.; but great care must be taken not to generate sulphurous acid, as is done very wastefully by the Fahlun and the Goslar processes. By the latter, indeed, not more than one or two parts of sulphur are obtained, by roasting 100 parts of the pyritous ores of the Rammelsberg mines. In these cases, the sulphur is burned, instead of being sublimed. The residuum of the operation, when it is well conducted, is black sulphuret of iron, which may be profitably employed for making copperas. The apparatus for extracting sulphur from pyrites should admit no more air than is barely necessary to promote the sublimation. **Sicily produced last year 70,000 tons of sulphur, and Tuscany 1200; of which Great Brit-**

ain consumed 46,000; France, 18,000; other places, 6,000. In 1820, Great Britain consumed only 5,000 tons.

SULPHURATION, is the process by which woollen, silk, and cotton goods are exposed to the vapors of burning sulphur, or to sulphurous acid gas. In the article STRAW-HAT MANUFACTURE, I have described a simple and cheap apparatus, well adapted to this operation.

Sulphuring-rooms are sometimes constructed upon a great scale, in which blankets, shawls, and woollen clothes may be suspended freely upon poles or cords. The floor should be flagged with a sloping pavement, to favor the drainage of the water that drops down from the moistened cloth. The iron or stoneware vessels, in which the sulphur is burned, are set in the corners of the apartment. They should be increased in number according to the dimensions of the place, and distributed uniformly over it. The windows and the entrance door must be made to shut hermetically close. In the lower part of the door there should be a small opening, with a sliding shutter, which may be raised or lowered by the mechanism of a cord passing over a pulley.

The aperture by which the sulphurous acid and azotic gases are let off, in order to carry on the combustion, should be somewhat larger than the opening at the bottom. A lofty chimney carries the noxious gases above the building, and diffuses them over a wide space, their ascension being promoted by means of a draught-pipe of iron, connected with an ordinary stove, provided with a valve to close its orifice when not kindled.

When the chamber is to be used, the goods are hung up, and a small fire is made in the draught-stove. The proper quantity of sulphur being next put into the shallow pans, it is kindled, the entrance door is closed, as well as its shutter, while a vent-hole near the ground is opened by drawing its cord, which passes over a pulley. After a few minutes, when the sulphur is fully kindled, that vent-hole must be almost entirely shut, by relaxing the cord; when the whole apparatus is to be let alone for a sufficient time.

The object of the preceding precautions is to prevent the sulphurous acid gas escaping from the chamber by the seams of the principal doorway. This is secured by closing it imperfectly, so that it may admit of the passage of somewhat more air than can enter by the upper seams, and the smallest quantity of fresh air that can support the combustion. The velocity of the current of air may be increased at pleasure, by enlarging the under vent-hole a little, and quickening the fire of the draught-stove.

Before opening the entrance door of the apartment, for the discharge of the goods, a small fire must be lighted in the draught furnace, the vent-hole must be thrown entirely open, and the sliding shutter of the door must be slid up, gradually more and more every quarter of an hour, and finally left wide open for a proper time. By this means the air of the chamber will become soon respirable.

SULPHURETED HYDROGEN, is a gas, composed of one part of hydrogen and sixteen parts of sulphur, by weight. Its specific gravity is 1·1912, compared to air=1·0000. It is the active constituent of the sulphurous mineral waters. When breathed, it is very deleterious to animal life; and being nearly twice as dense as air, it may be poured from its generating bottle into cavities; a scheme successfully employed by M. Thenard to destroy rats in their holes.

SULPHURIC ACID, *Vitriolic Acid*, or *Oil of Vitriol*, (*Acide sulfurique*, Fr.; *Schwefelsaüre*, Germ.) This important product, the agent of many chemical operations, was formerly procured by the distillation of dried sulphate of iron, called green vitriol, whence the corrosive liquid which came over, having an oily consistence, was denominated oil of vitriol. This method has been superseded in Great Britain, France, and most other countries, by the combustion of sulphur along with nitre, in large leaden chambers; but as the former process, which is still practised at Bleyl in Bohemia, and Nordhausen in Saxony, gives birth to some interesting results, I shall describe it briefly.

Into a long horizontal furnace, or gallery of brickwork, a series of earthenware retorts, of a pear shape, is arranged, with curved necks fitted into stoneware bottles or condensers. Each retort is charged with sulphate of iron, which has been previously heated to moderate redness. The first product of the distillation, a slightly acidulous phlegm, is allowed to escape; then the retort and receiver are securely luted together. The fire is now raised, and urged briskly for thirty-six hours, whereby the strong sulphuric acid is expelled, in the form of heavy white vapors, which condense in the cold receiver into an oily-looking liquid. The latter portions, when received in a separate refrigerator, frequently concrete into a crystalline mass, formerly called glacial oil of vitriol. About sixty four pounds of strong acid may be obtained from six hundred pounds of copperas. It is brown-colored; and varies in specific gravity from 1·842 to 1·896. Its boiling point is so low as 120° Fahr. When re-distilled in a glass retort, into a receiver surrounded with ice, a very moderate heat sends over white fumes, which condense into a soft solid, in silky filaments, like asbestos, tough, and difficult to cut. When this is exposed to the air, it emits copious fumes of sulphuric (not sulphurous) acid. It burns holes in paper as rapidly as a red-hot iron. Dropped in small quantities into water, it excites a hissing noise, like ignited metal; and in larger quantities, it occasions an explosion. By dropping a fragment of it into a poised vial containing water, and stoppering instantly, to prevent the ejection of liquid, by the ebullition which always ensues, I got a dilute acid, containing a known portion of the solid acid, from the specific gravity of which, as well as from its saturating power, I ascertained that the above solid sulphuric acid was truly anhydrous (*void of water*), consisting of 1 equivalent proportion of sulphur, and 3 of oxygen; or, by weight, of 16 of the former, and 24 of the latter. This acid makes a red solution of indigo.

The production of sulphuric acid from sulphur and nitre may be elegantly illustrated by means of a glass globe with a stoppered hole at its side, and four bent glass tubes inserted into a leaden cap in its upper orifice. The first tube is to be connected with a heated matrass, disengaging sulphurous acid from copper filings and sulphuric acid; the second with a retort, disengaging more slowly deutoxyde of azote (nitric oxyde) from copper filings and nitric acid; the third with a vessel for furnishing steam in a moderate current towards the end of the process, when no water has been previously admitted into the balloon; the fourth tube may be upright, and terminate in a small funnel. Through the opening in the side of the globe, atmospherical air is to be admitted from time to time, by removing the stopper; after which, the residuary lighter azote may be allowed to escape by the funnel orifice.

The nitric oxyde first absorbs oxygen from the air, becomes, in consequence, nitrous acid vapor, which giving up one third of its oxygen to the sulphurous acid, converts this, with the aid of water, into sulphuric acid, while itself returning to the state of nitric oxyde, is again qualified to take oxygen from the air, and to transfer it to the sulphurous acid gas; and thus in perpetual rotation. These oxygenating and disoxygenating processes continue until nearly the whole oxygen of the atmospheric air contained in the globe is consumed. Were there little aqueous vapor present, those gases would soon cease to operate upon each other; for though the nitric oxyde became nitrous acid, this would oxygenate little of the sulphurous acid, because the three substances would condense into white crystals upon the sides of the balloon, like hoar frost upon a window-pane in winter. These indicate a deficiency of aqueous vapor, and an excess of nitrous acid. On the admission of steam, the crystals disappear, the sulphuric acid is liquefied, the nitrous acid is converted into nitric acid and nitric oxyde; the former of which combines with the water, while the latter is converted by the atmospheric oxygen into nitrous acid vapor. A certain quantity of water is therefore requisite to prevent the formation of that crystalline compound, which condenses the nitrous acid, and renders it inoperative in transforming fresh portions of sulphurous acid into sulphuric. On these principles alone is it possible to oxygenate the sulphurous acid, by the nitrous acid resuming and surrendering a dose of oxygen, in perpetual alternation.

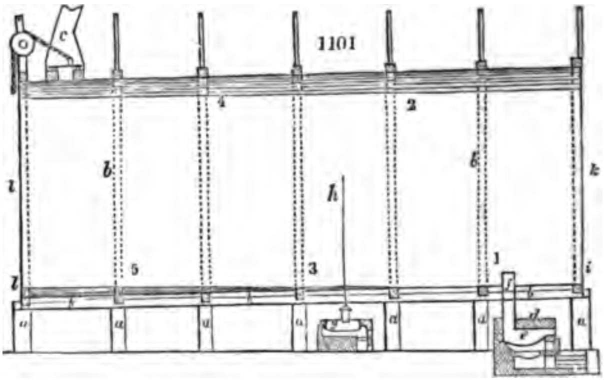
It was MM. Clement and Desormes who first had the sagacity to trace these complicated changes. They showed that nitrous acid gas and sulphurous acid gas mixed, react on each other through the intervention of moisture; that there resulted thence a combination of sulphuric acid, deutoxyde of azote (nitrous gas), and water; that this crystalline compound was instantly destroyed by more water, with the separation of the sulphuric acid in a liquid state, and the disengagement of nitrous gas; that this gas re-constituted nitrous acid at the expense of the atmospheric oxygen of the leaden chamber, and thus brought matters to their primary condition. From this point, starting again, the particles of sulphur in the sulphurous acid, through the agency of water, became fully oxygenated by the nitrous acid, and fell down in heavy drops of sulphuric acid, while the nitrous gas derived from the nitrous acid, had again recourse to the air for its lost dose of oxygen. This beautiful interchange of the oxygenous principle was found to go on, in their experiments, till either the sulphurous acid, or oxygen in the air, was exhausted.

They verified this proposition, with regard to what occurs in sulphuric acid chambers, by mixing in a crystal globe the three substances, deutoxyde of azote, sulphurous acid, and atmospheric air. The immediate production of red vapors indicated the transformation of the deutoxyde into nitrous acid gas; and now the introduction of a very little water caused the proper *reaction*, for opaque vapors rose, which deposited white star-form crystals on the surface of the glass. The gases were once more transparent and colorless; but another addition of water melted these crystals with effervescence, when ruddy vapors appeared. In this manner the phenomena were made to alternate, till the oxygen of the included air was expended, or all the sulphurous acid was converted into sulphuric. The residuary gases were found to be nitrous acid gas and azote, without sulphurous acid gas; while unctuous sulphuric acid bedewed the inner surface of the globe. Hence, they justly concluded their new theory of the manufacture of oil of vitriol to be demonstrated.

In consequence of their discovery, the manufacture of this acid has received such improvements, that a nearly double product of it may now be obtained from the same weight of materials. Indeed, the economy may be reckoned to be much greater; for one half of the more costly ingredient, the nitre, formerly employed with a given weight of sulphur, suffices at present.

In the manufacture of sulphuric acid upon the great scale, two different systems of working were long prevalent; the intermittent or periodical, and the continuous or uniform. Both were carried on in large leaden chambers. In the former, the chambers were closed during the period of combustion and gaseous combination, but were opened from time to time to introduce fresh atmospheric air. This method is, I believe, generally abandoned now, on account of the difficulties and delays attending it, though it afforded large products in skilful hands. In the latter, a continuous current of air is allowed to enter at the oven in front of the chamber for the combustion of the sulphur, and there is a constant escape of nitrogen gas, with a little sulphurous acid gas, at the remote end of the roof.

Fig. 1101 represents a sulphuric acid chamber. *a*, *a*, are the brick or stone pillars upon which it rests; *b*, *b*, are the sustaining wooden beams or joists; *c*, is the chimney for the discharge of the nitrogen; *d*, is the roof, and *e*, the sole of the hearth for the combustion of the sulphur; *f*, is the cylindrical tunnel, or pipe of lead or cast iron, for conducting the gasiform materials into the chamber; *g*, is the steam boiler; and *h*, the steam-pipe. That plan is variously modified, by different oil of vitriol makers in this country and in France. Very frequently, the oven *e*, *d*, is not situated under the chamber, but is built at the end of it, as at *i*, and arched over with brick, the crown being 9 inches thick. The pipe *f*, 18 inches in diameter, is then placed outside of the chamber, being inserted into a brick chimney, and, turning rectangularly, enters it opposite *k*. The sole of the hearth *e*, is a thick plate of cast iron (not hollowed as shown in the figure), 5 or 6 feet long, and 3 or 4 broad, with a small fireplace constructed beneath it, whose smoke-flue runs outwards, under the floor, to the side wall of the building. The oven is in this case about 2 feet in height, from the sole to the roof; and it has an iron door, about 12 inches by 15, which slides up and down in a tightly-fitted iron frame. This door is frequently placed in the side of the oven, parallel to the long side of the leaden chamber. A stout collar of lead is bolted to the chamber, where the pipe enters it. At the middle of the side of the chamber, about 2 feet above the ground, a leaden trough is fixed, which serves as a syphon-funnel and water-trap for introducing water to the acid gases.



Several manufacturers divide the chamber into a series of rectangular compartments, by parallel leaden screens, 10 or 12 feet asunder, and allow these compartments to communicate by a narrow opening, or a hole 1 foot square, in the top and bottom of each screen alternately. Thus the fumes, which enter from the chimney-pipe over *k*, will be forced, by the screen at *b*, to descend to 1, and pass through the opening there, to get into the second compartment, whence they will escape near the top at 2, thus circulating up and down, so as to occasion a complete agitation and intermixture of their heterogeneous particles. Into the side of the chamber, opposite to the centre of each compartment, a lead pipe enters, and proceeds towards the middle of the area, terminating in a narrow orifice, for discharging a jet of high-pressure steam from a boiler loaded with 40 pounds upon the square inch. This boiler should be placed under a shed exterior to the building. It deserves to be noted, that the incessant tremors produced in this pipe by the escape of the steam, cause the orifice to contract, and eventually to close almost entirely, just as the point of a glass tube does when exposed directly to the flame of a blowpipe. Provision should therefore be made against this event, by the chemical engineer.

Equidistant between the middle point and each end of the chamber, two round holes are cut out in its side, about 16 inches in diameter, and 2 feet from the floor; the sheet lead being folded back over the face of the strong deals which strengthen the chamber in that place. The edges of the holes are bevelled outwards, so as to fit a large conical plug of wood faced with lead, called a man-hole door. One or other of these doors is opened from time to time, to allow the superintendent to inspect the process, or workmen to enter, after the chamber is well ventilated, for the purpose of making repairs. The joists or tie-beams, that bind the rafters of the roof of both the leaden chamber and the house, must be at least 7 inches deep, by 3 broad, and of such length as to have their ends supported upon the outer wall, or the columnar supports of the roof, in case a number of chambers are enclosed together in parallel ranges under a vast shed. These beams, which lie two feet apart, suspend the leaden roof, by means of leaden straps soldered to its upper surface and edges. The sides of the chamber are sustained by means of similar leaden straps affixed to the wooden posts (uprights), 4 inches broad by 3 thick, placed two or three feet apart along the sides of the chamber; resting on the ground below, and mortised into the tie-beams above. Some chambers rest upon a sand-floor; but they are preferably placed upon wooden joists, supported by pillars stretching over an open area, as shown in the figure, into which the workmen may descend readily, to examine the bottom.

The outlet *c*, on the top of the chamber, is sometimes joined to a long pipe of lead laid nearly horizontally, with a slight inclination upwards, along the roof, for favoring the condensation and return of acid matter.

At the extremity *l*, of the chamber, which, having a downward slope of 1 inch in every 20 feet, should stand from 3 to 6 inches (according to its length) lower than *i*, one leg of an inverted syphon pipe is fixed by fusion, into which the liquid of the chamber passing, will show by its altitude the depth on the bottom within. From the cup-shaped orifice of that bent-up pipe, the acid of the chamber is drawn off by an ordinary leaden syphon into the concentration pans.

The sheet lead of which the sides and top are made should weigh from 5 to 6 pounds per square foot; that of the bottom should be nearly of double thickness.

Having now detailed, with sufficient minuteness, the construction of the chamber, I shall next describe the mode of operating with it. There are at least two plans at present in use for burning the sulphur continuously in the oven. In the one, the sulphur is laid on the hearth *e*, (or rather on the flat hearth in the separate oven, above described,) and is kindled by a slight fire placed under it; which fire, however, is allowed to go out after the first day, because the oven becomes by that time sufficiently heated by the sulphur flames to carry on the subsequent combustion. Upon the hearth, an iron tripod is set, supporting, a few inches above it, a hemispherical cast-iron bowl (basin) charged with nitre and its decomposing proportion of strong sulphuric acid. In the other plan, 12 parts of bruised sulphur, and 1 of nitre, are mixed in a leaden trough on the floor with 1 of strong sulphuric acid, and the mixture is shovelled through the sliding iron door upon the hot hearth. The successive charges of sulphur are proportioned, of course, to the size of the chamber. In one of the largest, which is 120 feet long, 20 broad, and 16 high, 12 cwts. are burned in the course of 24 hours, divided into 6 charges, every fourth hour, of 2 cwts. each. In chambers of one sixth greater capacity, containing 1400 metres cube, 1 ton of sulphur is burned in 24 hours. This immense production was first introduced at Chaunay and Dieuze, under the management of M. Clement-Desormes. The bottom of the chamber should be covered at first with a thin stratum of sulphuric acid, of spec. grav. 1·07, which decomposes nitrous acid into oxygen and nitrous gas; but not with more water, which would absorb the nitrous acid vapors, and withdraw them from their aerial sphere of action. The vapor of nitric acid, disengaged from the nitre on the hearth of the oven, when brought into intimate contact with the sulphurous acid, either gives up oxygen to it, becomes itself nitrous gas, and converts it into sulphuric acid; or combines with the sulphurous acid into the crystalline compound above described, which, the moment it meets with moisture, is decomposed into sulphuric acid and nitrous gas. The atmospherical oxygen of the chamber immediately reconverts this gas into nitrous or nitric acid fumes, which are again ready, with the co-operation of sulphurous acid gas and aqueous vapor, to produce fresh quantities of hydrous sulphuric acid (oil of vitriol) and nitrous gas. At low temperatures, this curious play of chemical affinities has a great tendency to form the crystalline compound, and to deposite it in a crust of considerable thickness (from one half to one inch) on the sides of the chamber, so as to render the process inoperative. A circumstance of this kind occurred, in a very striking manner, during winter, in a manufacture of oil of vitriol in Russia; and it has sometimes occurred, to a moderate extent, in Scotland. It is called, at Marseilles, the *maladie des chambres*. It may be certainly prevented, by maintaining the interior of the chamber, by a jet of steam, at a temperature of 100° F. When these crystals fall into the dilute acid at the bottom, they are decomposed with a violent effervescence, and a hissing gurgling noise, somewhat like that of a tun of beer in brisk fermentation.

M. Clement-Desormes demonstrated the proposition relative to the influence of temperature by a decisive experiment. He took a glass globe, furnished with three tubulures, and put a bit of ice into it. Through the first opening he then introduced sulphurous acid gas; through the second, oxygen; and through the third, nitrous gas (deutoxyde of azote). While the globe was kept cool, by being plunged in iced water, no sulphuric acid was formed, though all the ingredients essential to its production were present. But on exposing the globe to a temperature of 100° Fahr., the four bodies began immediately to react on each other, and oil of vitriol was condensed in visible *striæ*.

The introduction of steam is a modern invention, which has vastly facilitated and increased the production of oil of vitriol. It serves, by powerful agitation, not only to mix the different gaseous molecules intimately together, but to impel them against each other, and thus bring them within the sphere of their mutual chemical attraction. This is its mechanical effect. Its chemical agency is still more important. By supplying moisture at every point of the immense included space, it determines the formation of hydrous sulphuric acid, from the compound of nitric, nitrous, sulphurous, and dry sulphuric acids. No sooner is this reaction accomplished, than the nitrous gas resumes its oxygen, from the continuous atmospherical current, and becomes again fit to operate a like round of transmutations with sulphurous acid, steam, and oxygen. The nitrogen (azote), which ought to be the only residuum in a *perfectly* regulated vitriol chamber, escapes, by its relative lightness, at the opening *c*, in the roof, or, more properly speaking, is displaced by the influx of the heavier gases at the entrance-pipe.

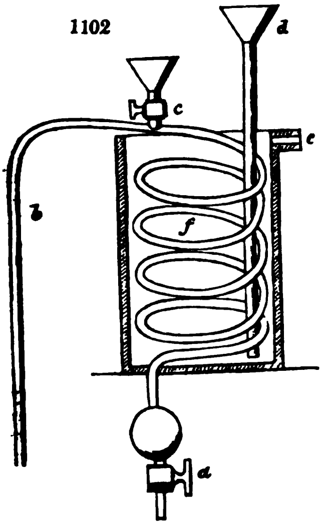
On the intermittent plan, after the consumption of each charge, and condensation of the product, the chamber was opened, and freely ventilated, so as to expel the residuary azote, and replenish it with fresh atmospheric air. In this system there were four distinct stages or periods:—1. Combustion for two hours; 2. Admission of steam, and settling, for an hour and a half; 3. Conversion, for three hours, during which interval the drops of strong acid were heard falling like heavy hailstones on the bottom; 4. Purging of the chamber, for three quarters of an hour.

By the continuous method, sulphuric acid may be currently obtained in the chambers, of the specific gravity 1·350, or 1·450 at most; for, when stronger, it absorbs and retains permanently much nitrous acid gas; but by the intermittent, so dense as 1·550, or even 1·620; whence in a district where fuel is high priced, as near Paris, this method recommended itself by economy in the concentration of the acid. In Great Britain, and even in most parts of France, however, where time, workmen's wages, and interest of capital, are the paramount considerations, manufacturers do not find it for their interest in general to raise the density of the acid in the chambers above 1·400, or at most 1·500; as the further increase goes on at a retarded rate, and its concentration from 1·400 to 1·600, in leaden pans, costs very little.

At about the specific gravity of 1·35, in Great Britain, the liquid of the chambers is run off, by the syphon above described, into a leaden gutter or spout, which discharges it into a series of rectangular vessels made of large sheets of lead, of 12 or 14 lbs. to the square foot, simply folded up at the angles into pans 8 or 10 inches deep, resting upon a grate made of a pretty close row of wrought-iron bars of considerable strength, under which the flame of a furnace plays. Where coals are very cheap, each pan may have a separate fire; but where they are somewhat dear, the flame, after passing under the lowest pan of the range, which contains the strongest acid (at about 1·600), proceeds upwards with a slight slope to heat the pans of weaker acid, which, as it concentrates, is gradually run down by syphons to replenish the lower pans, in proportion as their aqueous matter is dissipated. The 3 or 4 pans constituting the range are thus placed in a straight line, but each at a different level, terrace like; *en gradins*, as the French say.

When the acid has thereby acquired the density of 1·650, or 1·700 at most, it must be removed from the leaden evaporators, because, when of greater strength, it would begin to corrode them; and it is transferred into leaden coolers, or run through a long refrigeratory worm-pipe surrounded by cold water. In this state it is introduced into glass or platinum retorts, to undergo a final concentration, up to the specific gravity of 1·842, or even occasionally 1·845, in consequence of slight saline impurities. When glass retorts are used, they are set in a long sand-bath over a gallery furnace, resting on fire tiles, under which a powerful flame plays; and as the flue gradually ascends from the fire-place, near to which it is most distant from the tiles, to the remoter end, the heat acts with tolerable equality on the first and last retort in the range. When platinum stills are employed, they are fitted into the inside of cast-iron pots, which protect the thin bottom and sides of the precious metal. The fire being applied directly to the iron, causes a safe, rapid, and economical concentration of the acid. The iron pots, with their platinum interior, filled with concentrated boiling-hot oil of vitriol, are lifted out of the fire-seat by tackle, and let down into a cistern of cold water, to effect the speedy refrigeration of the acid, and facilitate its transvasion into carboys packed in osier baskets lined with straw. Sometimes, however, the acid is cooled by running it slowly off through a long platinum syphon, surrounded by another pipe filled with cold water. *Fig.* 1102 shows my contrivance for this purpose.

1102



The under stopcock *a*, being shut, and the leg *b*, being plunged to nearly the bottom of the still, the worm is to be filled with concentrated cold acid through the funnel *c*. If that stopcock is now shut, and *a* opened, the acid will flow out in such quantity as to rarefy the small portion of air in the upper part of the pipe *b*, sufficiently to make the hot acid rise up over the bend, and set the syphon in action. The flow of the fluid is to be so regulated by the stopcock *a*, that it may be greatly cooled in its passage by the surrounding cold water in the vessel *f*, which may be replenished by means of the tube and funnel *d*, and overflow at *e*.

A manufacturer of acid in Scotland, who burns in each chamber 210 pounds of sulphur in 24 hours, being at the rate of 420 pounds for 20,000 cubic feet (= nearly 2000 metres cube), has a product of nearly 3 pounds of concentrated oil of vitriol for every pound of sulphur and twelfth of a pound of nitre. The advantage of his process results, I conceive, from the lower concentration of the acid in the chambers, which favors its more rapid production.

The platinum retort admits of from 4 to 6 operations in a day, when it is well mounted and managed. It has a capital of platinum, furnished with a short neck, which conducts the disengaged vapors into a lead worm of condensation; and the liquid thus obtained is returned into the lead pans. Great care must be taken to prevent any particles of lead from getting into the platinum vessel, since at the temperature of boiling sulphuric acid, the lead unites with the precious metal, and thus causes holes in the retort. These must be repaired by soldering-on a plate of platinum with gold.

Before the separate oven or hearth for burning the sulphur in contact with the nitre was adopted, this combustible mixture was introduced into the chamber itself, spread on iron trays or earthen pans, supported above the water on iron stands. But this plan was very laborious and unproductive. It is no longer followed.

One of the characters of the good quality of sulphuric acid, is its dissolving indigo without altering its fine blue color.

Sulphuric acid, when well prepared, is a colorless and inodorous liquid, of an oily aspect, possessing a specific gravity, in its most concentrated state, of 1·842, when redistilled, but as found in commerce, of 1·845. It is eminently acid and corrosive, so that a single drop will communicate the power of reddening litmus to a gallon of water, and will produce an ulcer of the skin when allowed to remain upon it. If swallowed in its strongest state, in even a small quantity, it acts so furiously on the throat and stomach as to cause intolerable agony and speedy death. Watery diluents, mixed with chalk or magnesia, are the readiest antidotes. At a temperature of about 600° F., or a few degrees below the melting point of lead, it boils and distils over like water. This is the best method of procuring sulphuric acid free from the saline and metallic matters with which it is sometimes contaminated.

The affinity of sulphuric acid for water is so strong, that when exposed in an open saucer, it imbibes one-third of its weight from the atmosphere in 24 hours, and fully six times its weight in a few months. Hence it should be kept excluded from the air. If four parts, by weight, of the strongest acid be suddenly mixed with one part of water, both being at 50° F., the temperature of the mixture will rise to 300°; while, on the other hand, if four parts of ice be mixed with one of sulphuric acid, they immediately liquefy and sink the thermometer to 4° below zero. From the great attraction existing between this acid and water, a saucer of it is employed to effect the rapid condensation of aqueous vapor as it exhales from a cup of water placed over it; both standing under the exhausted receiver of an air-pump. By the cold produced by this unchecked evaporation in vacuo, the water is speedily frozen.

To determine the purity of sulphuric acid, let it be slowly heated to the boiling point of water, and if any volatile acid matter be present, it will evaporate, with its characteristic smell. The presence of saline impurity, which is the common one, is discovered by evaporating a given weight of it in a small capsule of platinum placed on red-hot cinders. If more than two grains remain out of 500, the acid may be reckoned to be impure. The best test for sulphuric acid, and the soluble salts into which it enters, is the nitrate of baryta, of which 182 parts are equivalent to 49 of the strongest liquid acid, or to 40 of the dry, as it exists in crystallized sulphate of potassa. One twenty thousandth part of a grain of the acid may be detected by the grayish-white cloud which baryta forms with it. 100 parts of the concentrated acid are neutralized by 143 parts of dry carbonate of potassa, and by 110 of dry carbonate of soda, both perfectly pure.

Of all the acids, the sulphuric is most extensively used in the arts, and is, in fact, the primary agent for obtaining almost all the others, by disengaging them from their saline combinations. In this way, nitric, muriatic, tartaric, acetic, and many other acids, are procured. It is employed in the direct formation of alum, of the sulphates of copper, zinc, potassa, soda; in that of sulphuric ether, of sugar by the saccharification of starch, and in the preparation of phosphorus, &c. It serves also for opening the pores of skins in tanning, for clearing the surfaces of metals, for determining the nature of several salts by the acid characters that are disengaged, &c.

According to the analysis of Dr. Thomson, the crystalline compound deposited occasionally in the leaden chambers above described consists of—

Sulphurous acid,	0·6387,	or 3 atoms.	Water - -	0·0733,	or 1 atom.
Sulphuric acid,	0·5290	2	Sulphate of lead,	0·0140.	
Nitric acid -	0·3450	1 atom.			

He admits that the proportion of water is a little uncertain; and that the presence of sulphurous acid was not proved by direct analysis. When heated with water, the crystalline matter disengages nitrous gas in abundance; lets fall some sulphate of lead; and the liquid is found to be sulphuric acid. When heated without water, it is decomposed with emission of nitrous gas and fuming nitric acid; leaving a liquid which, mixed with water, produces a brisk effervescence, consisting chiefly of nitrous gas.

The following Table shows the quantity of concentrated and dry sulphuric acid in 100 parts of dilute, at different densities, by my experiments, published in the Quarterly Journal of Science, for October, 1817:—

Liquid.	Spec. gravity.	Dry.	Liquid.	Spec. gravity.	Dry.	Liquid.	Spec. gravity	Dry.
100	1·8460	81·54	66	1·5503	53·82	32	1·2334	26·09
99	1·8438	80·72	65	1·5390	53·00	31	1·2260	25·28
98	1·8415	79·90	64	1·5280	52·18	30	1·2184	24·46
97	1·8391	79·09	63	1·5170	51·37	29	1·2108	23·65
96	1·8366	78·28	62	1·5066	50·55	28	1·2032	22·83
95	1·8340	77·46	61	1·4960	49·74	27	1·1956	22·01
94	1·8288	76·65	60	1·4860	48·92	26	1·1876	21·20
93	1·8235	75·83	59	1·4760	48·11	25	1·1792	20·38
92	1·8181	75·02	58	1·4660	47·29	24	1·1706	19·57
91	1·8026	74·20	57	1·4560	46·48	23	1·1626	18·75
90	1·8070	73·39	56	1·4460	45·66	22	1·1549	17·94
89	1·7986	72·57	55	1·4360	44·85	21	1·1480	17·12
88	1·7901	71·75	54	1·4265	44·03	20	1·1410	16·31
87	1·7815	70·94	53	1·4170	43·22	19	1·1330	15·49
86	1·7728	70·12	52	1·4073	42·40	18	1·1246	14·68
85	1·7640	69·31	51	1·3977	41·58	17	1·1165	13·86
84	1·7540	68·49	50	1·3884	40·77	16	1·1090	13·05
83	1·7425	67·68	49	1·3788	39·95	15	1·1019	12·23
82	1·7315	66·86	48	1·3697	39·14	14	1·0953	11·41
81	1·7200	66·05	47	1·3612	38·32	13	1·0887	10·60
80	1·7080	65·23	46	1·3530	37·51	12	1·0809	9·78
79	1·6972	64·42	45	1·3440	36·69	11	1·0743	8·97
78	1·6860	63·60	44	1·3345	35·88	10	1·0682	8·15
77	1·6744	62·78	43	1·3255	35·06	9	1·0614	7·34
76	1·6624	61·97	42	1·3165	34·25	8	1·0544	6·52
75	1·6500	61·15	41	1·3080	33·43	7	1·0477	5·71
74	1·6415	60·34	40	1·2999	32·61	6	1·0405	4·89
73	1·6321	59·52	39	1·2913	31·80	5	1·0336	4·08
72	1·6204	58·71	38	1·2826	30·98	4	1·0268	3·26
71	1·6090	57·89	37	1·2740	30·17	3	1·0206	2·446
70	1·5975	57·08	36	1·2654	29·35	2	1·0140	1·63
69	1·5868	56·26	35	1·2572	28·54	1	1·0074	0·8154
68	1·5760	55·45	34	1·2490	27·72			
67	1·5648	54·63	33	1·2409	26·91			

SUMACH (Eng. and Fr.; *Schmack*, Germ.) is the powder of the leaves, peduncles, and young branches of the *Rhus coriaria*, and *Rhus cotinus*, shrubs which grow in Hungary, the Bannat, and the Illyrian provinces. Both kinds contain tannin, with a little yellow coloring matter, and are a good deal employed for tanning light-colored leathers; but the first is the best. With mordants, it dyes nearly the same colors as galls. In calico-printing, sumach affords, with a mordant of tin, a yellow color; with acetate of iron, weak or strong, a gray or black; and with sulphate of zinc, a brownish-yellow. A decoction of sumach reddens litmus paper strongly; gives white flocks with the proto-muriate of tin; pale yellow flocks with alum; blue flocks with red sulphate of iron, with an abundant precipitate. In the south of France, the twigs and leaves of the *Coriaria myrthifolia* are used for dyeing, under the name of *rédoul*, or *rodou*.

SWEEP-WASHER is the person who extracts from the sweepings, potsherds, &c., of refineries of silver and gold, the small residuum of precious metal.

SYNTHESIS is a Greek word, which signifies combination, and is applied to the chemical action which unites dissimilar bodies into a uniform compound; as sulphuric acid and lime, into gypsum; or chlorine and sodium, into culinary salt.

SIRUP is a solution of sugar in water. Cane-juice, concentrated to a density of 1·300, forms a sirup which does not ferment in the transport home from the West Indies, and may be boiled and refined at one step into superior sugar-loaves, with eminent advantage to the planter, the refiner, and the revenue.

T.

TABBYING, or WATERING, is the process of giving stuffs a wavy appearance with the calender.

TACAMAHAC is a resin obtained from the *Fagura octandra*, a tree which grows in Mexico and the West Indies. It occurs in yellowish pieces, of a strong smell, and a bitterish aromatic taste. That from the island of Madagascar has a greenish tint.

TAFFETA is a light silk fabric, with a considerable lustre or gloss.

TAFIA is a variety of rum.

TALC is a mineral genus, which is divided into two species, the common and the indurated. The first occurs massive, disseminated in plates, imitative, or crystallized in small six-sided tables. It is splendent, pearly, or semi-metallic, translucent, flexible, but not elastic. It yields to the nail; spec. grav. 2·77. Before the blowpipe, it first whitens and then fuses into an enamel globule. It consists of—silica, 62; magnesia, 27; alumina, 1·5; oxyde of iron, 3·5; water, 6. Klaproth found 2¾ per cent. of potash in it. It is found in beds of clay-slate and mica slate, in Aberdeenshire, Banffshire, Perthshire, Salzburg, the Tyrol, and St. Gothard. It is an ingredient in rouge for the toilette, communicating softness to the skin. It gives the flesh polish to soft alabaster figures, and is also used in porcelain paste.

The second species, or talc-slate, has a greenish-gray color; is massive, with tabular fragments, translucent on the edges, soft, with a white streak; easily cut or broken, but is not flexible; and has a greasy feel. It occurs in the same localities as the preceding. It is employed in the porcelain and crayon manufactures; as also as a crayon itself, by carpenters, tailors, and glaziers.

TALLOW (*Suif*, Fr.; *Talg*, Germ.) is the concrete fat of quadrupeds and man. That of the ox consists of 76 parts of stearine, and 24 of oleine; that of the sheep contains somewhat more stearine. See Fat and Stearine.

Tallow imported into the United Kingdom, in 1836, 1,186,364 cwts. 1 qr. 4 lbs.; in 1837, 1,308,734 cwts. 1 qr. 4 lbs. Retained for home consumption, in 1836, 1,318,678 cwts. 1 qr. 25 lbs.; in 1837, 1,294,009 cwts. 2 qrs. 21 lbs. Duty received, in 1836, £208,284; in 1837, £204,377.

TALLOW, PINEY. See Piney Tallow.

TAMPING is a term used by miners to express the filling up of the hole which they have bored in a rock, for the purpose of blasting it with gunpowder. See Mines.

TAN, or TANNIC ACID. (*Tannin*, Fr.; *Gerbstoff*, Germ.) See its preparation and properties described under Galls.

The barks replete with this principle should be stripped with hatchets and bills, from the trunk and branches of trees, not less than 30 years of age, in spring, when their sap flows most freely. Trees are also sometimes barked in autumn, and left standing, whereby they cease to vegetate, and perish ere long; but afford, it is thought, a more compact timber. This operation is, however, too troublesome to be generally practised, and therefore the bark is commonly obtained from felled trees; and it is richer in tannin the older they are. The bark mill is described in Gregory's *Mechanics*, and other similar works.

The following **Table** shows the quantity of extractive matter and tan in 100 parts of the several substances:—

Substances.	In 480, by Davy.	In about 8 ounces, by Biggins.	In 100 parts, by Cadet de Gassincourt.	Substances.	In 480, by Davy.	In about 8 ounces, by Biggins.	In 100 parts, by Cadet de Gassincourt.
White inner bark of old oak	72	-	21	Bark of Cherry-tree - -	—	59	24
Do. young oak - - -	77			Do. Sallow - - - -	—	59	
Do. Spanish chestnut -	63	30		Do. Poplar - - - -	—	78	
Do. Leicester willow -	79			Do. Hazel - - -	—	79	
Colored or middle bark of oak - - -	19			Do. Ash - - - -	—	82	
Do. Spanish chestnut -	14			Do. trunk of Span chestnut	—	98	
Do. Leicester willow -	16			Do. Smooth oak - - -	—	104	
Entire bark of oak - -	29			Do. Oak, cut in spring -	—	108	
Do. Spanish chestnut -	21			Root of Tormentil - - -	—	-	46
Do. Leicester willow -	33	109		Cornus sanguinea of Canada	—	-	44
Do. Elm - - - -	13	28		Bark of Alder - - -	—	-	36
Do. Common willow - -	11	boughs, 31		Do. Apricot - - -	—	-	22
Sicilian sumach - - -	78	158		Do. Pomegranate - -	—	-	21
Malaga sumach - - -	79			Do. Cornish cherry-tree -	—	-	19
Souchong tea - - -	48			Do. Weeping willow - -	—	-	16
Green tea - - - -	41			Do. Bohemian olive - -	—	-	14
Bombay catechu - - -	261			Do. Tan shrub with myrtle leaves - -	—	-	12
Bengal catechu - - -	231			Do. Virginian sumach -	—	-	10
Nut-galls - - - -	127	-	46	Do. Green oak - - -	—	-	10
Bark of oak, cut in winter -	—	30		Do. Service-tree - - -	—	-	8
Do. beech - - - -	—	31		Do. Rose chestnut of Amer.	—	-	8
Do Elder - - - -	—	41		Do. Rose chestnut - -	—	-	6
Do. Plum-tree - - -	—	58		Do. Rose chestnut of Carolina - - -	—	-	6
Bark of the trunk of willow -	—	52					
Do. Sycamore - - -	—	53	16	Do. Sumach of Carolina -	—	-	5
Bark of Birch - - -	—	54					

TANNING (*Tanner*, Fr.; *Gärberei*, Germ.) is the art of converting skin into Leather, which see. It has been ascertained, beyond a doubt, that "the saturated infusions of astringent barks contain much less extractive matter, in proportion to their tannin, than the weak infusions; and when skin is quickly tanned (in the former), common experience shows that it produces leather less durable than leather slowly formed."* The older tanners, who prided themselves on producing a substantial article, were so much impressed with the advantages of slowly impregnating skin with astringent matter, that they employed no concentrated infusion (ooze) in their pits, but stratified the skins with abundance of ground bark, and covered them with soft water, knowing that its active principles are very soluble, and that, by being gradually extracted, they would penetrate uniformly the whole of the animal fibres, instead of acting chiefly upon the surface, and making brittle leather, as the strong infusions never fail to do. In fact, 100 pounds of skin, quickly tanned in a strong infusion of bark, produce 137 of leather; while 100 pounds, slowly tanned in a weak infusion, produce only 117½. The additional 19½ pounds weight in the former case serve merely to swell the tanner's bill, while they deteriorate his leather, and cause it to contain much less of the textile animal solid. Leather thus highly charged with tannin is, moreover, so spongy as to allow moisture to pass readily through its pores, to the great discomfort and danger of persons who wear shoes made of it. That the saving of time, and the increase of product, are temptations strong enough to induce many modern tanners to steep their skins in a succession of strong infusions of bark, is sufficiently intelligible; but that any shoemaker should be so ignorant or so foolish as to proclaim that his leather is made by a process so injurious to its quality, is unaccountably stupid.

TANTALUM is the rare metal, also called Columbium.

TAPESTRY is an ornamental figured textile fabric of worsted or silk, for lining the walls of apartments; of which the most famous is that of the Gobelins Royal Manufactory, near Paris.

TAPIOCA is a modification of starch, partially converted into gum, by heating and stirring cassava upon iron plates. See Cassava and Starch.

TAR (*Goudron*, Fr.; *Ther*, Germ.) is the viscid, brown-black, resino-oleaginous compound, obtained by distilling wood in close vessels, or in ovens of a peculiar construction. See Charcoal, Pitcoal, coking of, and Pyroligneous Acid. According to Reichenbach, tar contains the peculiar proximate principles, *paraffine*, *eupion*, *creosote*, *picamar*, *pittacal*, besides pyrogenous resin, or *pyretine*, pyrogenous oil, or *pyroleine*, and vinegar. The resin, oil, and vinegar are called empyreumatic, in common language.

Tar imported into the United Kingdom, in 1836, 9,797 lsts. 8 barrels; in 1837,

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* Sir H. Davy, on the Operation of Astringent Vegetables in Tanning.—*Phil. Trans.* 1803.

11,480lsts. 1 brl. Retained for home consumption, in 1836, 9,639lsts. 8 brls.; in 1837, 11,686lsts. 2 brls. Duty received, in 1836, £7,231; in 1837, £8,775.

TARRAS; see CEMENT, and MORTAR, HYDRAULIC.

TARTAR (*Tartre*, Fr.; *Weinstein*, Germ.), called also argal or argol, is the crude bitartrate of potassa, which exists in the juice of the grape, and is deposited from wines in their fermenting casks, being precipitated in proportion as the alcohol is formed, in consequence of its insolubility in that liquid. There are two sorts of argal known in commerce, the white, and the red; the former, which is of a pale-pinkish color, is the crust let fall by white wines; the latter is a dark-red, from red wines.

The crude tartar is purified, or converted into cream of tartar, at Montpellier, by the following process:—

The argal having been ground under vertical mill-stones, and sifted, one part of it is boiled with 15 of water, in conical copper kettles, tinned on the inside. As soon as it is dissolved, 3½ parts of ground pipe-clay are introduced. The solution being well stirred, and then settled, is drawn off into crystallizing vessels, to cool; the crystals found concreted on the sides and bottom are picked out, washed with water, and dried. The mother water is employed upon a fresh portion of argal. The crystals of the first crop are re-dissolved, re-crystallized, and exposed upon stretched canvass to the sun and air, to be bleached. The clay serves to abstract the coloring matter. The crystals formed upon the surface are the whitest, whence the name cream of tartar is derived.

Purified tartar, the bitartrate of potassa, is thus obtained in hard clusters of small colorless crystals, which, examined by a lens, are seen to be transparent 4-sided prisms. It has no smell, but a feebly acid taste; is unchangeable in the air, has a specific gravity of 1·953, dissolves in 16 parts of boiling water, and in 200 parts at 60° F. It is insoluble in alcohol. It consists of 24·956 potassa, 70·276 tartaric acid, and 4·768 water. It affords, by dry distillation, pyrotartaric acid, and an empyreumatic oil; while carbonate of potassa remains associated with much charcoal in the retort, constituting black flux. Tartar is used in dyeing, medicine, and for extracting—

TARTARIC ACID. (*Acide tartarique*, Fr.; *Weinsteinsäure*, Germ.) This is prepared by adding gradually to a boiling-hot solution of 100 parts of tartar, in a large copper boiler, 26 of chalk, made into a smooth pap with water. A brisk effervescence ensues, by the disengagement of the carbonic acid of the chalk, while its base combines with the acid excess in the tartar, and forms an insoluble precipitate of tartrate of lime. The supernatant liquor, which is a solution of neutral tartrate of potassa, must be drawn off by a syphon, and decomposed by a solution of chloride of calcium (muriate of lime.) 28½ parts of the dry chloride are sufficient for 100 of tartar. The tartrate of lime, from both processes, is to be washed with water, drained, and then subjected, in a leaden cistern, to the action of 49 parts of sulphuric acid, previously diluted with 8 times its weight of water; 100 of dry tartrate take 75 of oil of vitriol. This mixture, after digestion for a few days, is converted into sulphate of lime and tartaric acid. The latter is to be separated from the former by decantation, filtration through canvass, and edulcoration of the sulphate of lime upon the filter.

The clear acid is to be concentrated in leaden pans, by a moderate heat, till it acquires the density of 40° B. (spec grav. 1·38), and then it is run off, clear from any sediment, into leaden or stoneware vessels, which are set in a dry stove-room for it to crystallize. The crystals, being re-dissolved and re-crystallized, become colorless 6-sided prisms. In decomposing the tartrate of lime, a very slight excess of sulphuric acid must be employed; because pure tartaric acid would dissolve any tartrate of lime that may escape decomposition. Bone black, previously freed from its carbonate and phosphate of lime, by muriatic acid, is sometimes employed to blanch the colored solutions of the first crystals. Tartaric acid contains nearly 9 per cent. of combined water. It is soluble in two parts of water at 60°, and in its own weight of boiling water. In its dry state, as it exists in the tartrate of lime or lead, it consists of 36·8 of carbon, 3 of hydrogen, and 60·2 of oxygen. It is much employed in calico-printing, and for making sodaic powders.

TARTRATES are salts composed of tartaric acid, and oxydized bases, in equivalent proportions.

TAWING is the process of preparing the white skins of the sheep, doe, &c. See LEATHER.

TEA, *green*, contains 34·6 parts of tannin, 5·9 of gum, 5·7 of vegetable albumine, 51·3 of ligneous fibre, with 2·5 of loss; and *black* tea contains 40·6 of tannin, 6·3 of gum, 6·4 of vegetable albumine, 44·8 of ligneous fibre, with 2 of loss. The ashes contain silica, carbonate of lime, magnesia, and chloride of potassium.—*Frank.* Davy obtained 32·5 of extract from Souchong tea; of which 10 were precipitated by gelatine. He found 8·5 only of tannin in green tea. The latter chemist is most to be depended upon. Chemical analysis has not yet discovered that principle in tea, to which its exciting property is due.

*The Chinese method of making Black Tea in Upper Assam.**—In the first place, the youngest and most tender leaves are gathered; but when there are many hands and a great quantity of leaves to be collected, the people employed nip off with the forefinger and thumb the fine end of the branch with about four leaves on, and sometimes even more, if they look tender. These are all brought to the place where they are to be converted into tea; they are then put into a large, circular, open-worked bamboo basket, having a rim all round, two fingers broad. The leaves are thinly scattered in these baskets, and then placed in a frame-work of bamboo, in all appearance like the side of an Indian hut without grass, resting on posts, 2 feet from the ground, with an angle of about 25°. The baskets with leaves are put in this frame to dry in the sun, and are pushed up and brought down by a long bamboo with a circular piece of wood at the end. The leaves are permitted to dry about two hours, being occasionally turned; but the time required for this process depends on the heat of the sun. When they begin to have a slightly withered appearance, they are taken down and brought into the house, where they are placed on a frame to cool for half an hour. They are then put into smaller baskets of the same kind as the former, and placed on a stand. People are now employed to soften the leaves still more, by gently clapping them between their hands, with their fingers and thumb extended, and tossing them up and letting them fall, for about five or ten minutes. They are then again put on the frame during half an hour, and brought down and clapped with the hands as before. This is done three successive times, until the leaves become to the touch like soft leather; the beating and putting away being said to give the tea the black color and bitter flavor. After this the tea is put into hot cast-iron pans, which are fixed in a circular mud fireplace, so that the flame cannot ascend round the pan to incommode the operator. This pan is well heated by a straw or bamboo fire to a certain degree. About two pounds of the leaves are then put into each hot pan, and spread in such a manner that all the leaves may get the same degree of heat. They are every now and then briskly turned with the naked hand, to prevent a leaf from being burnt. When the leaves become inconveniently hot to the hand, they are quickly taken out and delivered to another man with a close-worked bamboo basket ready to receive them. A few leaves that may have been left behind are smartly brushed out with a bamboo broom; all this time a brisk fire is kept up under the pan. After the pan has been used in this manner three or four times, a bucket of cold water is thrown in, and a soft brickbat and bamboo broom used, to give it a good scouring out; the water is thrown out of the pan by the brush on one side, the pan itself being never taken off. The leaves, all hot on the bamboo basket, are laid on a table that has a narrow rim on its back, to prevent these baskets from slipping off when pushed against it. The two pounds of hot leaves are now divided into two or three parcels, and distributed to as many men, who stand up to the table with the leaves right before them, and each placing his legs close together; the leaves are next collected into a ball, which he gently grasps in his left hand, with the thumb extended, the fingers close together, and the hand resting on the little finger. The right hand must be extended in the same manner as the left, but with the palm turned downwards, resting on the top of the ball of tea leaves. Both hands are now employed to roll and propel the ball along; the left hand pushing it on, and allowing it to revolve as it moves; the right hand also pushes it forward, resting on it with some force, and keeping it down to express the juice which the leaves contain. The art lies here in giving the ball a circular motion, and permitting it to turn under and in the hand two or three whole revolutions. before the arms are extended to their full length, and drawing the ball of leaves quickly back without leaving a leaf behind, being rolled for about five minutes in this way. The ball of tea leaves is from time to time gently and delicately opened with the fingers, lifted as high as the face, and then allowed to fall again. This is done two or three times, to separate the leaves; and afterwards the basket with the leaves is lifted up as often, and receives a circular shake to bring these towards the centre. The leaves are now taken back to the hot pans, and spread out in them as before, being again turned with the naked hand, and when hot taken out and rolled; after which they are put into the drying basket, and spread on a sieve which is in the centre of the basket, and the whole placed over a charcoal fire. The fire is very nicely regulated; there must not be the least smoke, and the charcoal should be well picked.

When the fire is lighted, it is fanned until it gets a fine red glare, and the smoke is all gone off; being every now and then stirred and the coals brought into the centre, so as to leave the outer edge low. When the leaves are put into the drying basket, they are gently separated by lifting them up with the fingers of both hands extended far apart, and allowing them to fall down again; they are placed 3 or 4 inches deep on the sieve, leaving a passage in the centre for the hot air to pass. Before it is put over the fire, the drying basket receives a smart slap with both hands in the act of lifting it up, which is done to shake down any leaves that might otherwise drop through the sieve, or to prevent them from falling into the fire and occasioning a smoke, which would affect and spoil the tea. This slap on the basket is invariably applied throughout the stages of the tea manufacture. There is always a large basket underneath to receive the small leaves that fall, which are afterwards collected, dried, and added to the other tea; in no case are the baskets or sieves permitted to touch or remain on the ground, but always laid on a receiver with three legs. After the leaves have been half dried in the drying basket, and while they are still soft, they are taken off the fire and put into large open-worked baskets, and then put on the shelf, in order that the tea may improve in color.

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* By C. A. Bruce, superintendent of tea culture.

Next day the leaves are all sorted into large, middling, and small; sometimes there are four sorts. All these, the Chinese informed me, become so many different kinds of teas; the smallest leaves they called Pha-bo, the second, Pow-chong, the third Su-chong, and the fourth, or the largest leaves, Toy-chong. After this assortment they are again put on the sieve in the drying basket (taking great care not to mix the sorts), and on the fire, as on the preceding day; but now very little more than will cover the bottom of the sieve is put in at one time, the same care of the fire is taken as before, and the same precaution of tapping the drying basket every now and then. The tea is taken off the fire with the nicest care, for fear of any particle of the tea falling into it. Whenever the drying basket is taken off, it is put on the receiver, the sieve in the drying basket taken out, the tea turned over, the sieve replaced, the tap given, and the basket placed again over the fire. As the tea becomes crisp, it is taken out and thrown into a large receiving basket, until all the quantity on hand has become alike dried and crisp; from which basket it is again removed into the drying basket, but now in much larger quantities. It is then piled up eight and ten inches high on the sieve in the drying basket; in the centre a small passage is left for the hot air to ascend; the fire that was before bright and clear, has now ashes thrown on it to deaden its effect, and the shakings that have been collected are put on the top of all; the tap is given, and the basket with the greatest care is put over the fire. Another basket is placed over the whole, to throw back any heat that may ascend. Now and then it is taken off, and put on the receiver; the hands, with the fingers wide apart, are run down the sides of the basket to the sieve, and the tea gently turned over, the passage in the centre again made, &c., and the basket again placed on the fire. It is from time to time examined, and when the leaves have become so crisp that they break by the slightest pressure of the fingers, it is taken off, when the tea is ready. All the different kinds of leaves underwent the same operation. The tea is now little by little put into boxes, and first pressed down with the hands and then with the feet (clean stockings having been previously put on).

There is a small room inside of the tea-house, 7 cubits square and 5 high, having bamboos laid across on the top to support a net-work of bamboo, and the sides of the room smeared with mud to exclude the air. When there is wet weather, and the leaves cannot be dried in the sun, they are laid out on the top of this room, on the net-work, on an iron pan, the same as is used to heat the leaves; some fire is put into it, either of grass or bamboo, so that the flame may ascend high; the pan is put on a square wooden frame, that has wooden rollers on its legs, and pushed round and round this little room by one man, while another feeds the fire, the leaves on the top being occasionally turned; when they are a little withered, the fire is taken away, and the leaves brought down and manufactured into tea, in the same manner as if it had been dried in the sun. But this is not a good plan, and never had recourse to, if it can possibly be avoided.

Tea imported into the United Kingdom, in 1836, 49,307,701 lbs.; in 1837, 36,765,735 lbs. Retained for home comsumption, in 1836, 49,841,507 lbs.; in 1837, 31,872 lbs. Duty received, in 1836, £4,728,600; in 1837, £3,319,665.

TEASEL, the head of the thistle (*Dipsacus*), is employed to raise the nap of cloth. See WOOLLEN MANUFACTURE.

TEETH. See BONES.

TELLURIUM, is a metal, too rare and high-priced to be used in the arts.

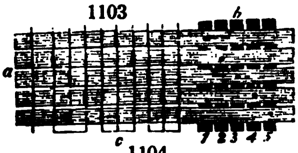
TERRA-COTTA, literally baked clay, is the name given to statues, architectural decorations, figures, vases, &c., modelled or cast in a paste made of pipe or potter's clay and a fine-grained colorless sand, from Ryegate, with pulverized potsherds, slowly dried in the air, and afterwards fired to a stony hardness in a proper kiln. See STONE, ARTIFICIAL.

TERRA DI SIENA, is a brown ferruginous ochre, employed in painting.

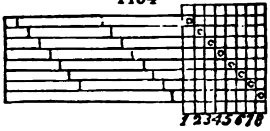
TESTS, are chemical reagents of any kind, which indicate, by special characters, the nature of any substance, simple or compound. See ASSAY, the several metals, acids, &c.

TEXTILE FABRICS. The first business of the weaver is to adapt those parts of his loom which move the warp, to the formation of the various kinds of ornamental figures which the cloth is intended to exhibit. This subject is called the *draught*, drawing or reading in, and the cording of looms. In every species of weaving, whether direct or cross, the whole difference of pattern or effect is produced, either by the succession in which the threads of warp are introduced into the heddles, or by the succession in which those heddles are moved in the working. The heddles being stretched between two shafts of wood, all the heddles connected by the same shafts are called a leaf; and as the operation of introducing the warp into any number of leaves is called drawing a warp, the plan of succession is called the draught. When this operation has been performed correctly, the next part of the weaver's business is to connect the different leaves with the levers or treddles by which they are to be moved, so that one or more may be raised or sunk by every treddle successively, as may be required to produce the peculiar pattern. These connexions being made by coupling the different parts of the apparatus by cords, this operation is called the cording. In order to direct the operator in this part of his business, especially if previously unacquainted with the particular pattern upon which he is employed, plans are drawn upon paper, specimens of which will be found in *figs.* 1103, 1104, &c. These plans are horizontal sections of a loom, the heddles being represented across the paper at *a*, and the treddles under them, and crossing them at right angles, at *b*. In *figs.* 1103 and 1104, they are represented as if they were distinct pieces of wood, those across being the under shaft of each leaf of heddles, and those at the left hand the treddles. See Weaving. In actual weaving, the treddles are placed at right angles to the heddles, the sinking cords descending perpendicularly as nearly as possible to the centre of the latter. Placing them at the left hand, therefore, is only for ready inspection, and for practical convenience. At *c* a few threads of warp are shown as they pass through the heddles, and the thick lines denote the leaf with which each thread is connected. Thus, in *fig.* 1103, the right-hand thread, next to *a*, passes through the eye of a heddle upon the back leaf, and is disconnected with all the other leaves; the next thread passes through a heddle on the second leaf; the third, through the third leaf; the fourth, through the fourth leaf; and the fifth, through the fifth or front leaf. One set of the draught being now completed, the weaver recommences with the back leaf, and proceeds in the same succession again to the front. Two sets of the draught are represented in this figure, and the same succession, it is understood by weavers (who seldom draw more than one set), must be repeated until all the warp is included. When they proceed to apply the cords, the right-hand part of the plan at *b* serves as a guide. In all the plans shown by these figures, excepting one which shall be noticed, a connexion must be formed, by cording, between every leaf of heddles and every treddle; for all the leaves must either rise or sink. The raising motion is effected by coupling the leaf to one end of its correspondent top lever; the other end of this lever is tied to the long march below, and this to the treddle. The sinking connexion is carried directly from under the leaf to the treddle. To direct a weaver which of these connexions is to be formed with each treddle, a black spot is placed when a leaf is to be raised, where the leaf and treddle intersect each other upon the plan, and the sinking connexions are left blank. For example, to cord the treddle 1, to the back leaf, put a raising cord, and to each of the other four, sinking cords; for the treddle 2, raise the second leaf, and sink the remaining four, and so of the rest; the spot always denoting the leaf or leaves to be raised. The *figs.* 1103, and 1104, are drawn for the purpose of rendering the general principle of this kind of plans familiar to those who have not been previously acquainted with them; but those who have been accustomed to manufacture and weave ornamented cloths, never consume time by representing either heddles or treddles as solid or distinct bodies. They content themselves with ruling a number of lines across a piece of paper, sufficient to make the intervals between these lines represent the number of leaves required. Upon these intervals, they merely mark the succession of the draught, without producing every line to resemble a thread of warp. At the left hand, they draw as many lines across the former as will afford an interval for each treddle; and in the squares produced by the intersections of these lines, they place the dots, spots, or ciphers which denote the raising cords. It is also common to continue the cross lines which denote the treddle a considerable length beyond the intersections, and to mark by dots, placed diagonally in the intervals, the order or succession in which the treddles are to be pressed down in weaving. The former of these modes has been adopted in the remaining *figs.* to 1112; but to save room, the latter has been avoided, and the succession marked by the order of the figures under the intervals which denote the treddles.

1103



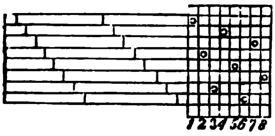
1104



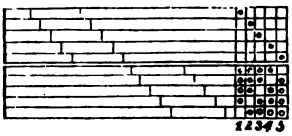
Some explanation of the various kinds of fanciful cloths represented by these plans, may serve further to illustrate this subject, which is, perhaps, the most important of any connected with the manufacture of cloth, and will also enable a person who thoroughly studies them, readily to acquire a competent knowledge of the other varieties in weaving, which are boundless. *Figs.* 1103 and 1104 represent the draught and cording of the two varieties of tweeled cloth wrought with five leaves of heddles. The first is the regular or run tweel, which, as every leaf rises in regular succession, while the rest are sunk, interweaves the warp and woof only at every fifth interval, and as the succession is uniform, the cloth, when woven, presents the appearance of parallel diagonal lines, at an angle of about 45° over the whole surface. A tweel may have the regularity of its diagonal lines broken by applying the cording as in *fig.* 1104. It will be observed, that in both figures the draught of the warp is precisely the same, and that the whole difference of the two plans consists in the order of placing the spots denoting the raising cords, the first being regular and successive, and the second alternate.

Figs. 1105 and 1106 are the regular and broken tweels which may be produced with eight leaves. This properly is the tweel denominated satin in the silk manufacture, although many webs of silk wrought with only five leaves receive that appellation. Some of the finest Florentine silks are tweeled with sixteen leaves.

1105

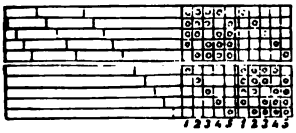


1106

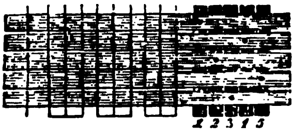


When the broken tweel of eight leaves is used, the effect is much superior to what could be produced by a smaller number; for in this, two leaves are passed in every interval, which gives a much nearer resemblance to plain cloth than the others. For this reason it is preferred in weaving the finest damasks. The draught of the eight-leaf tweel differs in nothing from the others, excepting in the number of leaves. The difference of the cording in the broken tweel, will appear by inspecting the ciphers which mark the raising cords, and comparing them with those of the broken tweel of five leaves. *Fig.* 1107 represents the draught and cording of striped dimity of a tweel of five leaves. This is the most simple species of fanciful tweeling. It consists of ten leaves, or double the number of the common tweel. These ten leaves are moved by only five treddles, in the same manner as a common tweel. The stripe is formed by one set of the leaves flushing the warp, and the other set, the woof. The figure represents a stripe formed by ten threads, alternately drawn through each of the two sets of leaves. In this case, the stripe and the intervals will be equally broad, and what is the stripe upon one side of the cloth, will be the interval upon the other, and *vice versâ*. But great variety of patterns may be introduced by drawing the warp in greater or smaller portions through either set. The tweel is of the regular kind, but may be broken by placing the cording as in *fig.* 1104. It will be observed that the cording-marks of the lower or front leaves are exactly the converse of the other set; for where a raising mark is placed upon one, it is marked for sinking in the other; that is to say, the mark is omitted; and all leaves which sink in the one, are marked for raising in the other: thus, one thread rises in succession in the back set, and four sink; but in the front set, four rise, and only one sinks. The woof, of course, passing over the four sunk threads, and under the raised one, in the first instance, is flushed above; but where the reverse takes place, as in the second, it is flushed below; and thus the appearance of a stripe is formed. The analogy subsisting between striped dimity and dornock is so great, that before noticing the plan for fancy dimity, it may be proper to allude to the dornock, the plan of which is represented by *fig.* 1108.

1107



1108



The draught of dornock is precisely the same in every respect with that of striped dimity. It also consists of two sets of tweeling-heddles, whether three, four, or five leaves are used for each set. The right hand set of treddles is also corded exactly in the same way, as will appear by comparing them. But as the dimity is a continued stripe from the beginning to the end of the web, only five treddles are required to move ten leaves. The dornock being checker-work, the weaver must possess the power of reversing this at pleasure. He therefore adds five more treddles, the cording of which is exactly the reverse of the former; that is to say, the back leaves in the former case, having one leaf raised, and four sunk, have, by working with these additional treddles, one leaf sunk and four leaves raised. The front leaves are in the same manner reversed, and the mounting is complete. So long as the weaver continues to work with either set, a stripe will be formed, as in the dimity; but when he changes his feet from one set to the other, the whole effect is reversed, and the checkers formed. The dornock pattern upon the design-paper, *fig.* 1108, may be thus explained: let every square of the design represent five threads upon either set of the heddles, which are said by weavers to be once over the draught, supposing the tweel to be one of five leaves; draw three parallel lines, as under, to form two intervals, each representing one of the sets; the draught will then be as follows:—

4		1		4		1		1		4		1	
	4		4		1		1		1		4		4

The above is exactly so much of the pattern as is there laid down, to show its appearance; but one whole range of the pattern is completed by the figure 1. nearest to the right hand upon the lower interval between the lines, and the remaining figures, nearer to the right, form the beginning of a second range or set. These are to be repeated in the same way across the whole warp. The lower interval represents the five front leaves; the upper interval, the five back ones. The first figure 4, denotes that five threads are to be successively drawn upon the back leaves, and this operation repeated four times. The first figure 4, in the lower interval, expresses that the same is to be done upon the front leaves; and each figure, by its diagonal position, shows how often, and in what succession, five threads are to be drawn upon the leaves which the interval in which it is placed represents.

Dornocks of more extensive patterns are sometimes woven with 3, 4, 5, and even 6 sets of leaves; but after the leaves exceed 15 in number, they both occupy an inconvenient space, and are very unwieldy to work. For these reasons the diaper harness is in almost every instance preferred.

Fig. 1109 represents the draught and cording of a fanciful species of dimity, in which it will be observed that the warp is not drawn directly from the back to the front leaf, as in the former examples; but when it has arrived at either external leaf, the draught is reversed, and returns gradually to the other. The same draught is frequently used in tweeling, when it is wished that the diagonal lines should appear upon the cloth in a zigzag direction. This plan exhibits the draught and cording which will produce the pattern upon the design-paper in *fig.* 1103, *a.* Were all the squares produced by the intersection of the lines denoting the leaves and treddles where the raised dots are placed, filled the same as on the design, they would produce the effect of exactly one fourth of that pattern. This is caused by the reversing of the draught, which gives the other side reversed as on the design; and when all the treddles, from 1 to 16, have been successively used in the working, one half of the pattern will become complete. The weaver then goes again over his treddles, in the reversed order of the numbers, from 17 to 30, when the other half of the pattern will be completed. From this similarity of the cording to the design, it is easy, when a design is given, to make out the draught and cording proper to work it; and when the cording is given, to see its effect upon the design.

1109

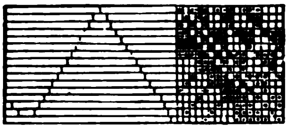


Fig. 1110 represents the draught of the diaper mounting, and the cording of the front leaves, which are moved by treddles. From the plan, it will appear that 5 threads are included in every mail of the harness, and that these are drawn in single threads through the front leaves. The cording forms an exception to the general rules, that when one or more leaves are raised, all the rest must be sunk; for in this instance, one leaf rises, one sinks, and three remain stationary. An additional mark, therefore, is used in this plan. The dots, as formerly, denote raising cords; the blanks, sinking cords; and where the cord is to be totally omitted, the cross marks X are placed.

1110

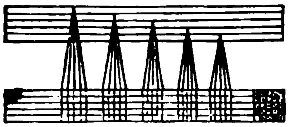
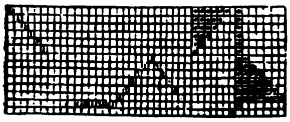


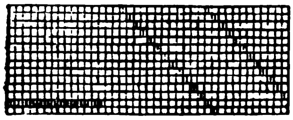
Fig. 1111 is the draught and cording of a spot whose two sides are similar, but reversed. That upon the plan forms a diamond, similar to the one drawn upon the design paper in the diagram, but smaller in size. The draught here is reversed, as in the dimity plan, and the treading is also to be reversed, after arriving at 6, to complete the diamond. Like it, too, the raising marks form one fourth of the pattern. In weaving spots, they are commonly placed at intervals, with a portion of plain cloth between them, and in alternate rows, the spots of one row being between those of the other. But as intervals of plain cloth must take place, both by the warp and woof, two leaves are added for that purpose. The front, or ground leaf, includes every second thread of the whole warp; the second, or plain leaf, that part which forms the intervals by the warp. The remaining leaves form the spots; the first six being allotted to one row of spots, and the second six to the next row; where each spot is in the centre between the former. The reversed draught of the first is shown entire, and is succeeded by 12 threads of plain. One half of the draught of the next row is then given, which is to be completed exactly like the first, and succeeded by 12 threads more of plain; when, one set of the pattern being finished, the same succession is to be repeated over the whole warp. As spots are formed by inserting woof of coarser dimensions than that which forms the fabric, every second thread only is allotted for the spotting. Those included in the front, or ground leaf, are represented by lines, and the spot threads between them, by marks in the intervals, as in the other plans.

1111



The treddles necessary to work this spot are, in number, 14. Of these, the two in the centre *a*, *b*, when pressed alternately, will produce plain cloth; for *b* raises the front leaf, which includes half of the warp, and sinks all the rest; while *a* exactly reverses the operation. The spot-treddles on the right hand work the row contained in the first six-spot leaves; and those upon the left hand, the row contained in the second six. In working spots, one thread, or shot of spotting-woof, and two of plain, are successively inserted, by means of two separate shuttles.

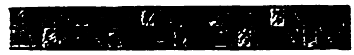
1112



Dissimilar spots, are those whose sides are quite different from each other. The draught only of these is represented by *fig.* 1112. The cording depends entirely upon the figure.

Fig. 1113 represents any solid body composed of parts *lashed* together. If the darkened squares be supposed to be beams of wood, connected by cordage, they will give a precise idea of textile fabric. The beams cannot come into actual contact, because, if the *lashing* cords were as fine even as human hairs, they must still require space. The thickness is that of one beam and one cord; but if the cords touch each other, it may then be one beam and two cords; but it is not possible in practical weaving to bring every thread of weft into actual contact. It may therefore be assumed, that the thickness is equal to the diameter of one thread of the warp, added to that of one yarn of the weft; and when these are equal, the thickness of the cloth is double of that diameter. Denser cloth would not be sufficiently pliant or flexible.

1113



1114

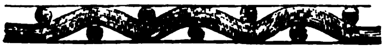
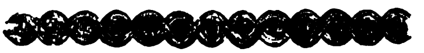


Fig. 1114 is a representation of a section of cloth of an open fabric, where the round dots which represent the warp are placed at a considerable distance from each other.

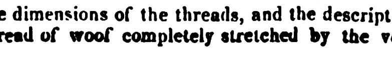
Fig. 1115 may be supposed a plain fabric of that description which approaches the most nearly to any idea we can form of the most dense or close contact of which yarn can be made susceptible. Here the warp is supposed to be so tightly stretched in the loom as to retain entirely the parallel state, without any curvature, and the whole flexure is therefore given to the woof. This mode of weaving can never really exist; but if the warp be sufficiently strong to bear any tight stretching, and the woof be spun very soft and flexible, something very near it may be produced. This way of making cloth is well fitted for those goods which require to give considerable warmth; but they are sometimes the means of very gross fraud and imposition; for if the warp is made of very slender threads, and the woof of slackly twisted cotton or woollen yarn, where the fibrils of the stuff, being but slightly brought into contact, are rough and oozy, a great appearance of thickness and strength may be given to the eye, when the cloth is absolutely so flimsy, that it may be torn asunder as easily as a sheet of writing-paper. Many frauds of this kind are practised.

1115



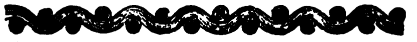
In *fig.* 1116 is given a representation of the position of a fabric of cloth in section, as it is in the loom before the warp has been closed upon the woof, which still appears as a straight line. This figure may usefully illustrate the direction and ratio of contraction which must unavoidably take place in every kind of cloth, according to the density of the texture, the dimensions of the threads, and the description of the cloth. Let A, B, represent one thread of woof completely stretched by the velocity of the shuttle in passing between

1116



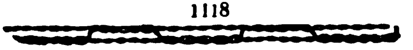
the threads of warp which are represented by the round dots 1, 2, &c., and those distinguished by 8, 9, &c. When these threads are closed by the operation of the heddles to form the inner texture, the first tendency will be to move in the direction 1, *b*, 2, *b*, &c., for those above, and in that of 8 *a*, 9 *a*, &c., for those below; but the contraction for A, B, by its deviation from a straight to a curved line, in consequence of the compression of the warp threads 1 *b*, 2 *b*, &c., and 1 *a*, 2 *a*, &c., in closing, will produce, by the action of the two powers at right angles to each other, the oblique or diagonal direction denoted by the lines 1, 8—2, 9, to the left, for the threads above, and that expressed by the lines 2, 8—3, 9, &c., to the right, for the threads below. Now, as the whole deviation is produced by the flexure of the thread A, B, if A is supposed to be placed at the middle of the cloth, equidistant from the two extremities, or *selvages*, as they are called by weavers, the thread at 1 may be supposed to move really in the direction 1 *b*, and all the others to approach to it in the directions represented, whilst those to the right would approach in the same ratio, but the line of approximation would be inverted. *Fig.* 1117 represents that common fabric used for lawns, muslins, and the middle kind of goods, the excellence of which neither consists in the greatest strength, nor in the greatest transparency. It is entirely a medium between *fig.* 1114 and *fig.* 1115.

1117



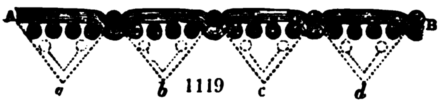
In the efforts to give great strength and thickness to cloth, it will be obvious that the common mode of weaving, by constant intersection of warp and woof, although it may be perhaps the best which can be devised for the former, presents invincible obstructions to the latter, beyond a certain limit. To remedy this, two modes of weaving are in common use, which, while they add to the power of compressing a great quantity of materials in a small compass, possess the additional advantage of affording much facility for adding ornament to the superficies of the fabric. The first of these is double cloth, or two webs woven together, and joined by the operation. This is chiefly used for carpets; and its geometrical principles are entirely the same as those of plain cloth, supposing the webs to be sewed together. A section of the cloth will be found in *fig.* 1118. See CARPET.

1118



Of the simplest kind of tweeled fabrics, a section is given in *fig.* 1119.

The great and prominent advantage of the tweeled fabric, in point of texture, arises from the facility with which a very great quantity of materials may be put closely together. In the figure, the warp is represented by the dots in the same straight line as in the plain fabrics; but if we consider the direction and ratio of contraction, upon principles similar to those laid down in the explanation given of *fig.* 1116, we shall readily discover the very different way in which the tweeled fabric is affected.

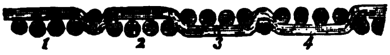


1119

When the dotted lines are drawn at *a*, *b*, *c*, *d*, their direction of contraction, instead of being upon every second or alternate thread, is only upon every fifth thread, and the natural tendency would consequently be, to bring the whole into the form represented by the lines and dotted circles at *a*, *b*, *c*, *d*. In point, then, of thickness, from the upper to the under superficies, it is evident that the whole fabric has increased in the ratio of nearly three to one. On the other hand, it will appear, that four threads or cylinders being thus put together in one solid mass, might be supposed only one thread, or like the strands of a rope before it is twisted; but, to remedy this, the thread being shifted every time, the whole forms a body in which much aggregate matter is compressed; but where, being less firmly united, the accession of strength acquired by the accumulation of materials is partially counteracted by the want of equal firmness of junction.

The second quality of the tweeled fabric, *susceptibility of receiving ornament*, arises from its capability of being inverted at pleasure, as in *fig.* 1120. In this figure we have, as before, four threads, and one alternately intersected; but here the four threads marked 1 and 2 are under the woof, while those marked 3 and 4 are above.

1120



1121

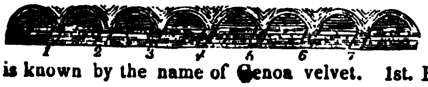


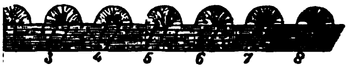
Fig. 1121 represents that kind of tweeled work which produces an ornamental effect, and adds even to the strength of a fabric, in so far as accumulation of matter can be considered in that light. The figure represents a piece of velvet cut in section, and of that kind which, being woven upon a tweeled ground, is known by the name of Genoa velvet. 1st. Because, by combining a great quantity ial in a small compass, they afford great warmth. 2d. From the great resist- ch they oppose to external friction, they are very durable. And 3d. Because, very nature of the texture, they afford the finest means of rich ornamental deco-

se of velvet cloths in cold weather is a sufficient proof of the truth of the first. ufacture of plush, corduroy, and other stuffs for the dress of those exposed to the of laborious employment, evinces the second; and the ornamented velvets and arpeting are demonstrative of the third of these positions.

figure, the diagonal form which both the warp and woof of cloth assume, is very from the smallness of the scale. Besides what this adds to the strength of the flushed part, which appears interwoven at the darkly shaded intervals, 1, 2, &c., hen finished, the whole covering or upper surface. The principle, in so far as exture, is entirely the same as any other tweeled fabric.

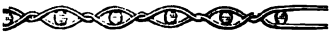
122, which represents corduroy, or king's cord, is merely striped velvet. The is the same, and the figure shows that the one is a copy of the other. The remaining figures represent those kinds of work which are of the most flimsy and open description of texture; those in which neither strength, warmth, nor durability is much required, and of which and transparency are the chief recommendations.

1122

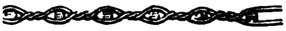


123 represents common gauze, or *linau*, a substance very much used for various . The essential difference between this description of cloth and all others, consists in the warp being turned or twisted like a rope during the operation of weaving, and hence it bears a considerable analogy to *lace*. The twining of gauze is nued in the same direction, but is alternately from right to left, and *vice versâ*, every intersection of the woof. The fabric of gauze is always open, flimsy, and nt; but, from the turning of the warp, it possesses an uncommon degree of and tenacity in proportion to the quantity of material which it contains. This ogether with the transparency of the fabric, renders it peculiarly adapted for or- purposes of various kinds, particularly for flowering or figuring, either in the by the needle. In the warp of gauze, there arises a much greater degree of on during the weaving, than in any other species of cloth; and this is produced rning. The twisting between every intersection of weft amounts precisely to one revolution of both threads; hence this difference exists between this and every other species of weaving, namely, that the one thread of warp is always above the woof, and the contiguous thread is always below.

1123



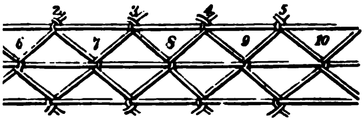
1124



124 represents a section of another species of twisted cloth, which is known by of catgut, and which differs from the gauze only by being subjected to a greater twine in weaving; for in place of one revolution between each intersection, a n and a half is always given; and thus the warp is alternately above and below, er kinds of weaving.

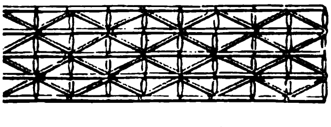
125 is a superficial representation of the most simple kind of ornamental net-work in the loom. It is called a whip-net by weavers, who use the term whip for any substance interwoven in cloth for ornamental purposes, when it is distinct from the ground of the fabric. In this, the difference is merely in the crossing of the warp; for it is very evident that the crossings at 1, 2, 3, 4, and 5, are of different threads from those at 6, 7, 8, and 9.

1125



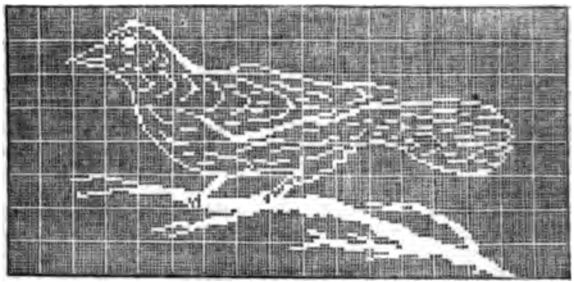
126 represents, superficially, what is called the mail-net, and is merely a combi- common gauze and the whip-net in the same fabric. The gauze here being in the same direction as the dotted line in the former figure, the whole fabric is evidently a continued succession of right-angled triangles, of which the woof forms the basis, the gauze part the perpendiculars, and the whip part the hypotenuses. The contraction here being very different, it is necessary that the gauze parts should be stretched upon separate beams.

1126



r to design ornamental figures upon cloths, the lines which are drawn from the top to the bottom of the paper may be supposed to represent the warp; and those drawn across, the woof of the web; any number of threads being supposed to be included between every two lines. The paper thus forms a double scale, by which, in the first instance, the size and form of the pattern may be determined with great precision; and the whole subsequent operations of the weaver regulated, both in mounting and working his loom. To enable the projector of a new pattern to judge properly of its effects, when transferred from the paper to the cloth, it will be essentially necessary that he should bear constantly in his view the comparative scale of magnitude which the design will bear in each, regulating his ideas always by square or superficial measurement. Thus, in the large design, *fig.* 1127, representing a bird perched upon the branch of a tree, it will be proper, in the first place, to count the number of spaces from the point of the bill to the extremity of the tail; and to render this the more easy, it is to be observed that every tenth line is drawn considerably bolder than the others. This number in the design is 135 spaces. Counting again, from the stem of the branch to the upper part of the bird's head, he will find 76 spaces. Between these spaces, therefore, the whole superficial measure of the pattern is contained. By the measure of the paper, this may be easily tried with a pair of compasses, and will be found to be nearly $6\frac{5}{10}$ inches in length, by $3\frac{3}{16}$ inches in breadth. Now, if this is to be woven in a reed containing 800 intervals in 37 inches, and if every interval contains five threads, supposed to be contained between every two parallel lines, the length will be 6·24 inches, and the breadth 3·52 inches nearly; so that the figure upon the cloth would be very nearly of the same dimensions as that upon the paper; but if a 1200 reed were used, instead of an 800, the dimensions would be proportionally contracted.

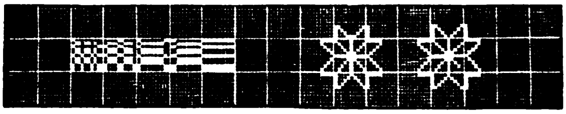
1127



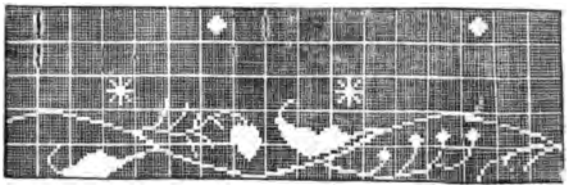
A correct idea being formed of the design, the weaver may proceed to mount his loom according to the pattern; and this is done by two persons, one of whom takes from the design the instructions necessary for the other to follow in tying his cords.

Fig. 1128 is a representation of the most simple species of table-linen, which is merely an imitation of checker-work of various sizes; and is known in Scotland, where the manufacture is chiefly practised, by the name of Dornock. When a pattern is formed upon tweeled cloth, by reversing the flushing, the two sides of the fabric being dissimilar, one may be supposed to be represented by the black marks, and the other by the part of the figure which is left uncolored. For such a pattern as this, two sets of common tweel-heddles, moved in the ordinary way, by a double succession of heddles, are sufficient. The other part of *fig.* 1128, is a design of that intermediate kind of ornamental work which is called diaper, and which partakes partly of the nature of the dornock, and partly of that of the damask and tapestry. The principle upon which all these descriptions of goods are woven is entirely the same, and the only difference is in the extent of the design, and the means by which it is executed. *Fig.* 1129 is a design for a border of a handkerchief or napkin, which may be executed either in the manner of damask, or as the spotting is practised in the lighter fabrics.

1128



1129



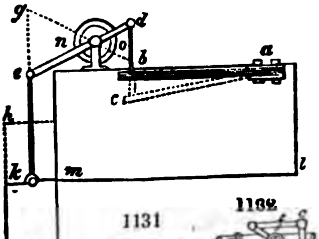
THENARD'S BLUE, or COBALT BLUE, is prepared by digesting the oxyde of cobalt used in the potteries, with nitric acid, evaporating the nitrate almost to dryness, diluting it with water, and filtering, to separate some arseniate of iron, which usually precipitates. The clear liquor is to be poured into a solution of phosphate of soda, whence an insoluble phosphate of cobalt falls. This being well washed, is to be intimately mixed in its soft state with eight times its weight of well-washed gelatinous alumina, which has been obtained by pouring a solution of alum into water of ammonia in excess. The uniformly colored paste is to be spread upon plates, dried in a stove, then bruised dry in a mortar, enclosed in a crucible, and subjected to a cherry-red heat for half an hour. On taking out the crucible, and letting it cool, the fine blue pigment is to be removed into a bottle, which is to be stopped till used.

The arseniate of cobalt may be substituted, in the above process, for the phosphate, but it must be mixed with sixteen times its weight of the washed gelatinous alumina. The arseniate is procured by pouring the dilute nitrate of cobalt into a solution of arseniate of potassa. If nitrate of cobalt be mixed with the alumina, and the mixture be treated as above described, a blue pigment will also be obtained, but paler than the preceding, showing that the color consists essentially of alumina stained with oxyde of cobalt.

THERMOMETER, signifies the measure of heat. Its description belongs to a treatise on chemical physics.

THERMOSTAT, is the name of an apparatus for regulating temperature, in vaporization, distillation, heating baths or hot-houses, and ventilating apartments, &c.; for which I obtained a patent in the year 1831. It operates upon the physical principle, that when two thin metallic bars of different expansibilities are riveted or soldered facewise together, any change of temperature in them will cause a sensible movement of flexure in the compound bar, to one side or other; which movement may be made to operate, by the intervention of levers, &c., in any desired degree, upon valves, stop-cocks, stove-registers, air-ventilators, &c.; so as to regulate the temperature of the media in which the said compound bars are placed. Two long rulers, one of steel, and one of hard hammered brass, riveted together, answer very well; the object being not simply to *indicate*, but to *control* or *modify* temperature. The following diagrams will illustrate a few out of the numerous applications of this instrument:—

1130



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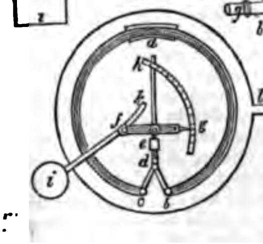

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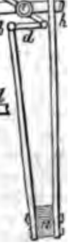


Fig. 1130, *a*, *b*, is a single thermostatic bar, consisting of two or more bars or rulers of differently expansible solids (of which, in certain cases, wood may be one): these bars or rulers are firmly riveted or soldered together, face to face. One end of the compound bar is fixed by bolts at *a*, to the interior of the containing cistern, boiler, or apartment, *a*, *l*, *m*, *b*, whereof the temperature has to be regulated, and the other end of the compound bar at *b*, is left free to move down towards *c*, by the flexure which will take place when its temperature is raised.

The end *b*, is connected by a link, *b*, *d*, with a lever *d*, *e*, which is moved by the flexure into the dotted position *b*, *g*, causing the turning-valve, air-ventilator, or register, *o*, *n*, to revolve with a corresponding angular motion, whereby the lever will raise the equipoised slide-damper *k*, *i*, which is suspended by a link from the end *e*, of the lever *e*, *d*, into the position *k*, *h*. Thus a hot-house or a water-bath may have its temperature regulated by the contemporaneous admission of warm, and discharge of cold air, or water.

Fig. 1131, *a*, *b*, *c*, is a thermostatic hoop, immersed horizontally beneath the surface of the water-bath of a still. The hoop is fixed at *a*, and the two ends *b*, *c*, are connected by two links *b*, *d*, *c*, *d*, with a straight sliding rod *d*, *h*, to which the hoop will give an endwise motion, when its temperature is altered; *e*, is an adjusting screw-nut on the rod *d*, *h*, for setting the lever *f*, *g*, which is fixed on the axis of the turning-valve or cock *f*, at any desired position, so that the valve may be opened or shut at any desired temperature, corresponding to the widening of the points *b*, *c*, and the consentaneous retraction of the point *d*, towards the circumference *a*, *b*, *c*, of the hoop. *g*, *h*, is an arc graduated by a thermometer, after the screw-piece *e* has been adjusted. Through a hole at *h*, the guide-rod passes. *i*, is the cold-water cistern; *i*, *f*, *k*, the pipe to admit cold water; *l*, the overflow pipe, at which the excess of hot water runs off.

Fig. 1132 shows a pair of thermostatic bars, bolted fast together at the ends *a*. The free ends *b*, *c*, are of unequal length, so as to act by the cross links *d*, *f*, on the stop-cock *e*. The links are jointed to the handle of the turning plug of the cock, on opposite sides of its centre; whereby that plug will be turned round in proportion to the widening of the points *b*, *c*. *h*, *g*, is the pipe communicating with the stop-cock.

Suppose that for certain purposes in pharmacy, dyeing, or any other chemical art, a water-bath is required to be maintained steadily at a temperature of 150° F.; let the combined thermostatic bars, hinged together at *e*, *f*, *fig*. 1133, be placed in the bath, between the outer and inner vessels *a*, *b*, *c*, *d*, being bolted fast to the inner vessel at *g*; and have their sliding rod *k*, connected by a link with a lever fixed upon the turning plug of the stop-cock *i*, which introduces cold water from a cistern *m*, through a pipe *m*, *i*, *n*, into the bottom part of the bath. The length of the link must be so adjusted that the flexure of the bars, when they are at a temperature of 150°, will open the said stop-cock, and admit cold water to pass into the bottom of the bath through the pipe *i*, *n*, whereby hot water will be displaced at the top of the bath through an open overflow-pipe at *q*. An oil bath may be regulated on the same plan; the hot oil overflowing from *q*, into a refrigeratory worm, from which it may be restored to the cistern *m*. When a water bath is heated by the distribution of a tortuous steam pipe through it, as *i*, *n*, *o*, *p*, it will be necessary to connect the link of the thermostatic bars with the lever of the turning plug of the steam-cock, or of the throttle valve *i*, in order that the bars, by their flexure, may shut or open the steam passage more or less, according as the temperature of the water in the bath shall tend more or less to deviate from the pitch to which the apparatus has been adjusted. The water of the condensed steam will pass off from the sloping winding-pipe *i*, *n*, *o*, *p*, through the sloping orifice *p*. A saline, acid, or alkaline bath has a boiling temperature proportional to its degree of concentration, and may therefore have its heat regulated by immersing a thermostat in it, and connecting the working part of the instrument with a stop-cock *i*, which will admit water to dilute the bath whenever by evaporation it has become concentrated, and has acquired a higher boiling point. The space for the bath, between the outer and inner pans, should communicate by one pipe with the water-cistern *m*; and by another pipe, with a safety cistern *r*, into which the bath may be allowed to overflow during any sudden excess of ebullition.

1133

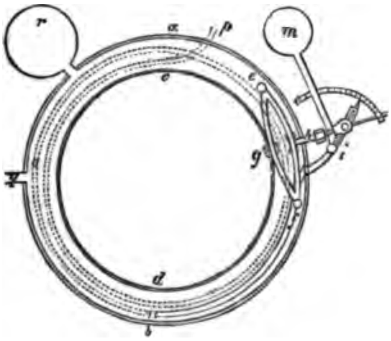
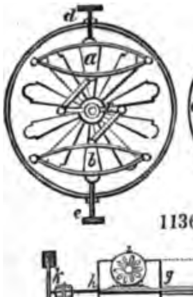


Fig. 1136 is a thermostatic apparatus, composed of three pairs of bars, *d*, *d*, *d*, which are represented in a state of flexure by heat; but they become nearly straight and parallel when cold. *a*, *b*, *c*, is a guide rod, fixed at one end by an adjusting screw *e*, in the strong frame *f*, *e*, having deep guide grooves at the sides. *f*, *g*, is the working-rod, which moves endways when the bars *d*, *d*, *d*, operate by heat or cold. A square register-plate *h*, *g*, may be affixed to the rod *f*, *g*, so as to be moved backwards and forwards thereby, according to the variations of temperature; or the rod *f*, *g*, may cause the circular turning air-register *i*, to revolve by rack and wheel-work, or by a chain and pulley. The register-plate *h*, *g*, or turning register *i*, is situated at the ceiling or upper part of the chamber, and serves to let out hot air. *k*, is a pulley, over which a cord runs to raise or lower a hot-air register *l*, which may be situated near the floor of the apartment or hot-house, to admit hot air into the room. *c*, is a milled head for adjusting the thermostat, by means of the screw at *e*, in order that it may regulate the temperature to any degree.

1134



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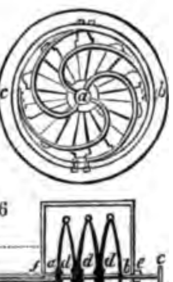

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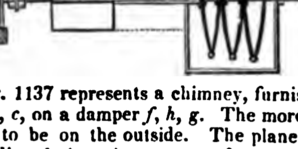


Fig. 1137 represents a chimney, furnished with a *pyrostat*, *a*, *b*, *c*, acting by the links *b*, *d*, *e*, *c*, on a damper *f*, *h*, *g*. The more expansible metal is in the present example supposed to be on the outside. The plane of the damper-plate will, in this case, be turned more directly into the passage of the draught through the chimney by increase of temperature.

Fig. 1135 represents a circular turning register, such as is used for a stove, or stove-grate, or for ventilating apartments; it is furnished with a series of spiral thermostatic bars, each bar being fixed fast at the circumference of the circle *b*, *c*, of the fixed plate of the air-register; and all the bars act in concert at the centre *a*, of the twining part of the register, by their ends being inserted between the teeth of a small pinion, or by being jointed to the central part of the turning plate by small pins.

1137

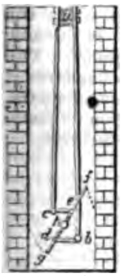


Fig. 1134 represents another arrangement of my thermostatic apparatus applied to a circular turning register, like the preceding, for ventilating apartments. Two pairs of compound bars are applied so as to act in concert, by means of the links *a c*, *b c*, on the opposite ends of a short lever, which is fixed on the central part of the turning plate of the air-register. The two pairs of compound bars *a b*, are fastened to the circumference of the fixed plate of the turning register, by two sliding rods *a d*, *b e*, which are furnished with adjusting screws. Their motion or flexure is transmitted by the links *a c*, and *b c*, to the turning plate, about its centre, for the purpose of shutting or opening the ventilating sectorial apertures, more or less, according to the temperature of the air which surrounds the thermostatic turning register. By adjusting the screws *a d*, and *b c*, the turning register is made to close all its apertures at any desired degree of temperature; but whenever the air is above that temperature, the flexure of the compound bars will open the apertures.

THIMBLE (*Dé à coudre*, Fr.; *Fingerhut* (*fingerhat*), Germ.), is a small truncated metallic cone, deviating little from a cylinder, smooth within, and symmetrically pitted on the outside with numerous rows of indentations, which is put upon the tip of the middle finger of the right hand, to enable it to push the needle readily and safely through cloth or leather, in the act of sewing. This little instrument is fashioned in two ways; either with a pitted round end, or without one; the latter, called the open thimble, being employed by tailors, upholsterers, and, generally speaking, by *needle-men*. The following ingenious process for making this essential implement, the contrivance of MM. Rouy and Berthier, of Paris, has been much celebrated, and very successful. Sheet-iron, one twenty-fourth of an inch thick, is cut into strips, of dimensions suited to the intended size of the thimbles. These strips are passed under a punch-press, whereby they are cut into discs of about 2 inches diameter, tagged together by a tail. Each strip contains one dozen of these blanks. A child is employed to make them red-hot, and to lay them on a mandril nicely fitted to their size. The workman now strikes the middle of each with a round-faced punch, about the thickness of his finger, and thus sinks it into the concavity of the first mandril. He then transfers it successively to another mandril, which has five hollows of successively increasing depth; and, by striking it into them, brings it to the proper shape.

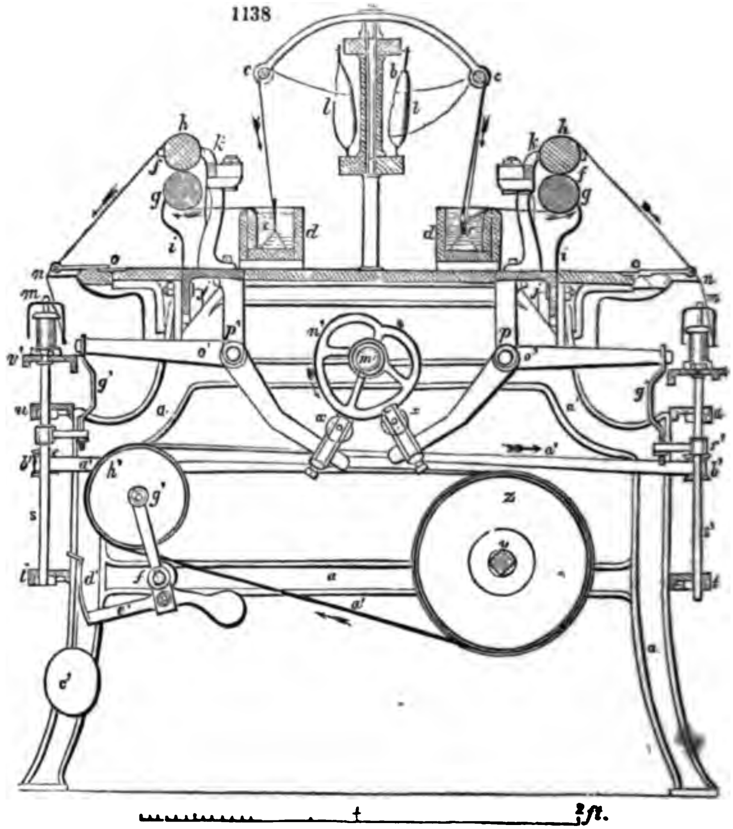
A second workman takes this rude thimble, sticks it in the chuck of his lathe, in order to polish it within, then turns it outside, marks the circles for the gold ornament, and indents the pits most cleverly with a kind of milling tool. The thimbles are next annealed, brightened, and gilt inside, with a very thin cone of gold leaf, which is firmly united to the surface of the iron, simply by the strong pressure of a smooth steel mandril. A gold fillet is applied to the outside, in an annular space turned to receive it, being fixed, by pressure at the edges, into a minute groove formed on the lathe.

Thimbles are made in this country by means of moulds in the stamping-machine. See Stamping of Metals.

THORINA is a primitive earth, with a metallic basis, discovered in 1828, by Berzelius. It was extracted from the mineral *thorite*, of which it constitutes 58 per cent., and where it is associated with the oxydes of iron, lead, manganese, tin, and uranium, besides earths and alkalis, in all 12 substances. Pure thorina is a white powder, without taste, smell, or alkaline reaction on litmus. When dried and calcined, it is not affected by either the nitric or muriatic acid. It may be fused with borax into a transparent glass, but not with potash or soda. Fresh precipitated thorina is a hydrate, which dissolves readily in the above acids, as well as in solutions of the carbonates of potash, soda, and ammonia, but not in these alkalis in a pure state. This earth consists of 74·5 parts of the metal *thorinum*, combined with 100 of oxygen. Its hydrate contains one equivalent prime of water. It is hitherto merely a chemical curiosity, remarkable chiefly for a density of 9·402, far greater than that of all the earths, and even of copper.

THREAD MANUFACTURE. The doubling and twisting of cotton or linen yarn into a compact thread, for weaving bobbinet, or for sewing garments, is performed by a machine resembling the throstle of the cotton-spinner. *Fig.* 1138 shows the thread-frame in a transverse section, perpendicular to its length. *a*, is the strong framing of cast-iron; *b*, is the *creel*, or shelf, in which the bobbins of yarn *l*, *l*, are set loosely upon their respective skewers, along the whole line of the machine, their lower ends turning in oiled steps, and their upper in wire eyes; *c*, is a glass rod, across which the yarn runs as it is unwound; *d*, *d*, are oblong narrow troughs, lined with lead, and filled with water, for moistening the thread during its torsion; the threads being made to pass through eyes at the bottom of the fork *e*, which has an upright stem for lifting it out, without wetting the fingers, when any thing goes amiss; *f*, *f*, are the pressing rollers, the under one *g*, being of smooth iron, and the upper one *h*, of box-wood; the former extends from end to end of the frame, in lengths comprehending 18 threads, which are joined by square pieces, as in the drawing-rollers of the mule-jenny. The necks of the under rollers are supported, at the ends and the middle, by the standards *i*, secured to square bases *j*, both made of cast iron. The upper cylinder has an iron axis, and is formed of as many rollers as there are threads; each roller being kept in its place upon the lower one by the guides *k*, whose vertical slots receive the ends of the axes.

1138



The yarn delivered by the bobbin *l*, glides over the rod *c*, and descends into the trough *d*, *e*, where it gets wetted; on emerging, it goes along the bottom of the roller *g*, turns up, so as to pass between it and *h*, then turns round the top of *h*, and finally proceeds obliquely downwards, to be wound upon the bobbin *m*, after traversing the guide-eye *n*. These guides are fixed to the end of a plate, which may be turned up by a hinge-joint at *o*, to make room for the bobbins to be changed.

There are three distinct simultaneous movements to be considered in this machine: 1. that of the rollers, or rather of the under roller, for the upper one revolves merely by friction; 2. that of the spindles *m*, *s'*; 3. the up-and-down motion of the bobbins upon the spindles.

The first of these motions is produced by means of toothed wheels, upon the right hand of the under set of rollers. The second motion, that of the spindles, is effected by the drum *z*, which extends the whole length of the frame, turning upon the shaft *v*, and communicating its rotatory movement (derived from the steam pulley) to the whorl *b'*, of the spindles, by means of the endless band or cord *a.'* Each of these cords turns four spindles, two upon each side of the frame. They are kept in a proper state of tension by the weights c', which act tangentially upon the circular arc d', fixed to the extremity of the bell-crank lever $e' f' g'$, and draw in a horizontal direction the tension pulleys h, embraced by the cords. The third movement, or the vertical traverse of the bobbins, along the spindles m, takes place as follows:—

The end of one of the under rollers carries a pinion, which takes into a carrier wheel, that communicates motion to a pinion upon the extremity of the shaft m', of the heart-shaped pulley n'. As this eccentric revolves, it gives a reciprocating motion to the levers $o' o'$, which oscillate in a vertical plane round the points $p' p'$. The extremities of these levers, on either side, act by means of the links q', upon the arms of the sliding sockets r', and cause the vertical rod s', to slide up and down in guide-holes at t', u', along with the cast-iron step v', which bears the bottom washer of the bobbins. The periphery of the heart-wheel n', is seen to bear upon friction wheels x, x', set in frames adjusted by screws upon the lower end of the bent levers, at such a distance from the point p', as that the traverse of the bobbins may be equal to the length of their barrel.

By adapting change pinions and their corresponding wheel to the rollers, the delivery of the yarn may be increased or diminished in any degree, so as to vary the degree of twist put into it by the uniform rotation of the drum and spindles. The heart motion, being derived from that of the rollers, will necessarily vary with it.

Silk thread is commonly twisted in lengths of from 50 to 100 feet, with hand reels, somewhat similar to those employed for making ropes by hand.

TILES. See BRICKS.

TILTING OF STEEL. See STEEL. Rees's Cyclopædia contains an excellent article on this subject.

TIN (*Etain*, Fr.; *Zinn*, Germ.), in its pure state, has nearly the color and lustre of silver. In hardness it is intermediate between gold and lead; it is very malleable, and may be laminated into foil less than the thousandth of an inch in thickness; it has an unpleasant taste, and exhales on friction a peculiar odor; it is flexible in rods or straps of considerable strength, and emits in the act of bending a crackling sound, as if sandy particles were intermixed, called the creaking of tin. A small quantity of lead, or other metal, deprives it of this characteristic quality. Tin melts at 442° Fahr., and is very fixed in the fire at higher heats. Its specific gravity is 7·29. When heated to redness with free access of air, it absorbs oxygen with rapidity, and changes first into a pulverulent gray protoxyde, and by longer ignition, into a yellow-white powder, called *putty* of tin. This is the peroxyde, consisting of 100 of metal + 27·2 of oxygen.

Tin has been known from the most remote antiquity; being mentioned in the books of Moses. The Phœnicians carried on a lucrative trade in it with Spain and Cornwall.

There are only two ores of tin; the peroxyde, or tin-stone, and tin pyrites; the former of which alone has been found in sufficient abundance for metallurgic purposes. The external aspect of tin-stone has nothing very remarkable. It occurs sometimes in twin crystals; its lustre is adamantine; its colors are very various, as white, gray, yellow, red, brown, black; specific gravity 6·9 at least; which is, perhaps, its most striking feature. It does not melt by itself before the blowpipe; but is reducible in the smoky flame or on charcoal. It is insoluble in acids. It has somewhat of a greasy aspect, and strikes fire with steel.

Tin-stone occurs disseminated in the ancient rocks, particularly granite; also in beds and veins, in large irregular masses, called *stockwerks*; and in pebbles, an assemblage of which is called stream-works, where it occasionally takes a ligneous aspect, and is termed *wood-tin*.

This ore has been found in few countries in a workable quantity. Its principal localities are, Cornwall, Bohemia, Saxony, in Europe; and Malacca and Banca, in Asia. The tin-mines of the Malay peninsula lie between the 10th and 6th degree of south latitude; and are most productive in the island of Junck-Ceylon, where they yield sometimes 800 tons per annum, which are sold at the rate of 48*l*. each. The ores are found in large caves near [illegible] surface; and though actively mined for many centuries, still there is easy access to the unexhausted parts. The mines in the island of Banca, to the east of Sumatra, discovered in 1710, are said to have furnished, in some years, nearly 3500 tons of tin. Small quantities occur in Gallicia in Spain, in the department of Haute Vienne in France, and in the mountain chains of the Fichtel and Riesengebürge in Germany. The columnar pieces of pyramidal tin-ore from Mexico and Chile, are products of stream-works. Small groups of black twin crystals have been lately discovered in the albite rock of Chesterfield in Massachusetts.

The Cornish ores occur—1. in small strata or veins, or in masses; 2. in stockwerks, or congeries of small veins; 3. in large veins; 4. disseminated in alluvial deposites.

The stanniferous small veins, or thin flat masses, though of small extent, are sometimes very numerous, interposed between certain rocks, parallel to their beds, and are commonly called tin-floors. The same name is occasionally given to stockwerks. In the mine of Bottalack, a *tin-floor* has been found in the killas (primitive schistose rock), thirty-six fathoms below the level of the sea; it is about a foot and a half thick, and occupies the space between a principal vein and its ramification; but there seems to be no connexion between the *floor* and the great vein.

2. Stockwerks occur in granite and in the feldspar porphyry, called in Cornwall, *elvan*. The most remarkable of these in the granite, is at the tin-mine of Carclase, near *St. Austle*. The works are carried on in the open air, in a friable granite, containing feldspar disintegrated into *kaolin*, or china clay, which is traversed by a great many small veins, composed of tourmaline, quartz, and a little tin-stone, that form black delineations on the face of the light-gray granite. The thickness of these little veins rarely exceeds 6 inches, including the adhering solidified granite, and is occasionally much less. Some of them run nearly east and west, with an almost vertical dip; others, with the same direction, incline to the south at an angle with the horizon of 70 degrees.

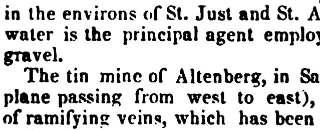
Stanniferous stockwerks are much more frequent in the elvan (porphyry), of which the mine of Trewidden-ball is a remarkable example. It is worked among flattened masses of *elvan*, separated by strata of *killas*, which dip to the east-north-east at a considerable angle. The tin ore occurs in small veins, varying in thickness from half an inch to 8 or 9 inches, which are irregular, and so much interrupted, that it is difficult to determine either their direction or their inclination.

3. The large and proper metalliferous veins are not equally distributed over the surface of Cornwall and the adjoining part of Devonshire; but are grouped into three districts; namely, 1. In the south-west of Cornwall, beyond Truro; 2. In the neighborhood of St. Austle; and 3. In the neighborhood of Tavistock in Devonshire.

The first group is by far the richest, and the best explored. The formation most abundant in tin mines is principally granitic; whilst that of the copper mines is most frequently schistose or killas; though with numerous exceptions. The great tin veins are the most ancient metalliferous veins in Cornwall; yet they are not all of one formation, but belong to two different systems. Their direction is, however, nearly the same, but some of them dip towards the north, and others towards the south. The first are older than the second; for in all the mines where these two sets of veins are associated, the one which dips to the north, cuts across and throws out the one which dips to the south. See MINES, p. 841.

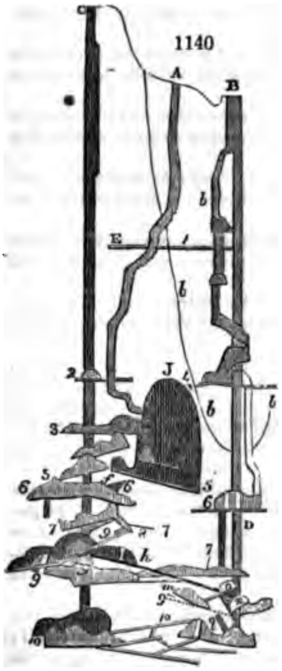
At Trevannance mines, the two systems of tin veins are both intersected by the oldest of the copper veins; indicating the prior existence of the tin veins. In *fig.* 1139, *b*, marks the first system of tin veins; *c*, the second; and *d*, the east and west copper veins. Some of these tin veins, as at Poldice, have been traced over an extent of two miles; and they vary in thickness from a small fraction of an inch to several feet, the average width being from 2 to 4 feet; though this does not continue uniform for any length, as these veins are subject to continual narrowings and expansions. The gangue is quartz, chlorite, tourmaline, and sometimes decomposed granite and fluor spar.

1139



4. *Alluvial tin ore, stream tin.*—Peroxyde of tin occurs disseminated both in the *alluvium* which covers the gentle slopes of the hills adjoining the rich tin-mines, and also in the alluvium which fills the valleys that wind round their base; but in these numerous deposites the tin-stone is rarely distributed in sufficient quantities to make it worth the working. The most important explorations of *alluvial tin ore* are grouped in the environs of St. Just and St. Austle; where they are called *stream-works*; because water is the principal agent employed to separate the metallic oxyde from the sand and gravel.

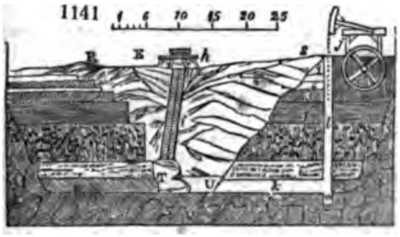
The tin mine of Altenberg, in Saxony (*fig.* 1140, which is a vertical projection in a plane passing from west to east), is remarkable for a stockwerk, or interlaced mass of ramifying veins, which has been worked ever since the year 1458. The including rock is a primitive porphyry, superposed upon gneiss; becoming very quartzose as it approaches the lode. This is usually disseminated in minute particles, and accompanied with wolfram, copper, and arsenical pyrites, *fer oligiste*, sulphuret of molybdenum, and bismuth, having gangues of lithomarge, fluor spar, mica, and feldspar. The space which the ore occupies in the heart of the quartz, is a kind of dædalus, the former being often so dispersed among the latter as to seem to merge into it; whence it is called by the workmen *zwitter*, or *ambiguous*. In 1620, the mine was worked by 21 independent companies, in a most irregular manner, whereby it was damaged to a depth of 170 fathoms by a dreadful downfall of the roofs. This happened on a Sunday, providentially, when the pious miners were all at church. The depth of this abyss, marked by the curved line *b*, *b*, *b*, is 66 fathoms; but the devastation is manifest to a depth of 95 fathoms below that curve, and 35 fathoms below the actual workings, represented at the bottom of the shaft under B. The parts excavated are shaded black in the figure. There are two masses of ore, one under the shaft B, and another under the shaft C; which at the levels 5 and 10 are in communication, but not at 6, 7. There is a direct descent from 8 to 9. The deposites are by no means in one vertical plane, but at a considerable horizontal distance from each other. A is the descending shaft; B is the extraction shaft, near the mouth of which there is a water-wheel; C is another extraction shaft, worked also by means of a water-wheel. A and C are furnished with ladders, but for B the ladders are placed in an accessory shaft *b′*; under D a shaft is sunk for pumping out the water, by means of an hydraulic wheel at D; E is the gallery or drift for admitting the water which drives the wheels. This falls 300 feet, and ought to be applied to a water-pressure engine, instead of the paddles of a wheel. At D is the gallery of discharge for the waters, which serves also to ventilate the mine, being cut to the day, through 936 toises of syenitic porphyry and gneiss. J is a great vaulted excavation. The mine has 13 stages of galleries, of which 11 serve for extracting the ore; 1 is the mill-course; the rest are marked with the numbers 2, 3, 4, &c.; each having besides a characteristic German name. The rare mineral called *topaz pycnite* is found in this mine, above 10, between the shafts C and D.



The only rule observed in taking ore from this mine has been to work as much out of each of these levels as is possible, without endangering the superincumbent or collateral galleries; on which account many pillars are constructed to support the roofs. The mine yields annually 1600 quintals (Leipzick) of tin, being four fifths of the whole furnished by the district of Altenberg; to produce which, 400,000 quintals of ore are raised. 1000 parts of the rock yield 8 of concentrated schlich, equivalent to only 4 of metal; being only 1 in 250 parts.

But the most extensive and productive stream-works are those of Pentowan, near St. Austle.

Fig. 1141 represents a vertical section of the Pentowan mine, taken from the *stream-work, Happy Union.* A vast excavation, R, T, U, *s*, has been hollowed out in the open air, in quest of the alluvial tin ore, T, which occurs here at an unusual depth, below the level of the strata R, *s*. Before getting at this deposite, several successive layers had to be sunk through; namely, 1, 2, 3; the gravel, containing in its middle a band of ochreous earth 2, or ferruginous clay; 4, a black peat, perfectly combustible, of a coarse texture, composed of reeds and woody fibres, cemented into a mass by a fine loam; 5, coarse sea-sand, mingled with marine shells; 6, a blackish marine mud, filled with shells. Below these the deposite of tin-stone occurs, including fragments of various size, of clay slate, flinty slate, quartz, iron ore, jasper; in a word, of all the rocks and gangues to be met with in the surrounding territory, with the exception of granite. Among these fragments there occur, in rounded particles, a coarse quartzose sand, and the tin-stone, commonly in small grains and crystals. Beneath the bed T, the clay slate occurs, called *killas*, (A, X, Y,) which supports all the deposites of more recent formation.



The system of mining is very simple. The successive beds, whose thickness is shown in the figure, are visibly cut out into steps or platforms. By a level or gallery of efflux, *k*, the waters flow into the bottom of the well *l*, *m*, which contains the drainage pumps; and these are put in action by a machine, *j*, moved by a water-wheel. The extraction of the ore is effected by an inclined plane, *i*, cut out of one of the sides of the excavation, at an angle of about 45 degrees. At the lower end of this sloping pathway there is a place of loading; and at its upper end *h*, a horse-gin, for alternately raising and lowering the two baskets of extraction on the pathway *i*.

Mine tin requires peculiar care in its mechanical preparation or dressing, on account of the presence of foreign metals, from which, as we have stated, the stream tin is free.

1. As the mine tin is for the most part extremely dispersed through the gangue, it must be all stamped and reduced to a very fine powder, to allow the metallic particles to be separated from the stony matters.

2. As the density of tin-stone is much greater than that of most other metallic ores, it is less apt to run off in the washing; and may, therefore, be dressed so as to be completely stripped of every matter not chemically combined.

3. As the peroxyde of tin is not affected by a moderate heat, it may be exposed to calcination; whereby the specific gravity of the associated sulphurets and arseniurets is so diminished as to facilitate their separation.

We may therefore conclude, that tin ore should be first of all pounded very fine in the stamp-mill, then subjected to reiterated washings, and afterwards calcined. The order of proceeding in Cornwall is as follows:—

1. *Cleaning the ore.*—This is usually done at the mouth of the gallery of efflux, by agitating the ore in the stream of water as it runs out. Sometimes the ore is laid on a grating, under a fall of water.

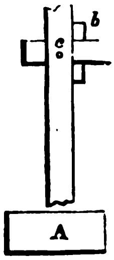
2. *Sorting.*—The ore thus cleaned, is sorted on the grate, into four heaps: 1. stones rich in tin; 2. stones containing both tin and copper ore; 3. copper ore; 4. sterile pieces, composed in a great measure of stony gangue, with iron and arsenical pyrites. In those veins where there is no copper ore, the second and third heaps are obviously absent. When present, the compound ore is broken into smaller pieces with a mallet, and the fragments are sorted anew.

3. *Stamping.*—The stanniferous fragments (No. 1) are stamped into a sand, of greater or less fineness, according to the dissemination of the tin-stone in the gangue. The determination of the size of the sand is an object of great importance. It is regulated by a copper plate pierced with small holes, through which every thing from the stamping-mill must run off with the rapid stream introduced for this purpose. This plate forms the front of the stamp cistern.

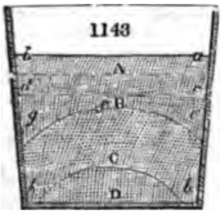
Several years ago, all the stamp-mills were driven by water-wheels, which limited the quantity of ore that could be worked to the hydraulic power of the stream or waterfall; but since the steam engine has been applied to this purpose, the annual product of tin has been greatly increased. On the mine of Huel Vor, there are three steam engines appropriated to the stamping-mills. Their force is 25 horses at least. One of these machines, called *south stamps*, drives 48 pestles; a second, called *old stamps*, drives 36; and a third, 21. The weight of these pestles varies from 370 to 387 pounds; and they generally rise through a space of 10½ inches. The machine called *south stamps*, the strongest of the three, gives 17½ blows in the minute, each pestle being lifted twice for every stroke of the piston. The steam engine of this mill has a power of 25 horses, and it consumes 1062 bushels of coals in the month. Three pestles constitute a battery, or stamp-box.

Washing and stamping of tin ores at Polgooth, near St. Austle.—The stamps or pestles are of wood, 6 inches by 5½ in the square: they carry lifting bars *b*, secured with a wooden wedge and a bolt of iron, and they terminate below in a lump of cast iron A, called the head, which is fastened to them by a tail, and weighs about 2½ cwts. The shank of the pestle is strengthened with iron hoops. A turning-shaft communicates motion to the stamps by cams stuck round its circumference, so arranged that the second falls while the first and third of each set are uplifted. There are 4 cams on one periphery, and the shaft makes 7 turns in the minute. Each stamp, therefore, gives 28 strokes per minute, and falls through a space of 7½ inches. The stamp chest is open behind, so that the ore slips away under the pestles, by its weight, along the inclined plane with the stream of water. The bottom of the troughs consists of stamped ores. With 6 batteries of 6 pestles each, at Poldice, near Redruth, 120 bags of ore are stamped in 12 hours; each bag containing 18 gallons of 282 cubic inches; measuring altogether 352 cubic feet, and 864 cubic inches.

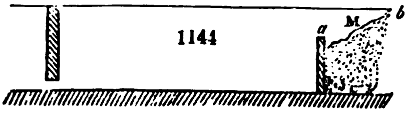
1142



The openings in the front sides of the troughs are nearly eight inches by seven and a half; they are fitted with an iron frame, which is closed with sheet iron, pierced with about 160 holes in the square inch, bored conically, being narrower within. The ore, on issuing, deposites its *rough* in the first basin, and its slimes in the following basins. The rough is washed in *buddles* (see Lead, page 757), and in *tossing-tubs*; the slimes in *trunks*, and upon a kind of twin tables, called *racks*. Into the *tossing-tub*, or *dolly*, *fig.* 1143, the stamped ore is thrown, along with a certain quantity of water, and a workman stirs it about with an iron shovel for three or four minutes. He then removes a little of the water with a handled pitcher, and strikes the sides of the tub for 8 or 10 minutes with a hammer, which hastens the subsidence of the denser parts. The water is next poured off by inclining the tub to one side. In one operation of this kind, four distinct strata of the ores may be procured, as indicated by the lines *a b*, *c d*, *e f g*, *h i k*, in the figure. The portion B is to be washed again in the *trunking-box*, *figs.* 1144, 1145; B is to be washed upon the German chests or racks, *fig.* 1146; C, the most considerable, is put aside, as schlich fit for the market; D, forming a nucleus in the centre of the tub, is to be passed through sieves of copper wire, having 18 meshes in the square inch. This product thus affords a portion D′, which passes through the sieve, and D″ which remains upon it; the latter is sometimes thrown away, and at others is subjected to the operation called the *tie*, viz., a washing upon the sloping bottom of a long trough.


1143

The slimes are freed from the lighter mud in the trunking-box, *figs.* 1144, 1145; which is from 7 to 8 feet long. Being accumulated at M, the workman pushes them back with a shovel from *a* towards *b*. The metallic portion is carried off, and deposited by the stream of water upon the table; but the earthy matters are floated along into a basin beyond it. The product collected in the chest is divided into two portions; the one of which is washed once, and the other twice, upon the *rack*, *fig.* 1146. This is composed of a frame C, which carries a sloping board or table, susceptible of turning round to the right or left upon two pivots, K, K. The head of the table is the inclined plane T. A small board P, which is attached by a band of leather L, forms the communication with the lower table C, whose slope is generally 5 inches in its whole length of 9 feet; but this may vary with the nature of the ore, being somewhat less when it is finely pulverized. The ore is thrown upon T, in small portions of 20 or 25 lbs. A woman spreads it with a rake, while a stream of water sweeps a part of it upon the table, where it gets washed. The fine mud falls through a cross slit near the lower end, into a basin B. After working for a few minutes, should the schlich seem tolerably rich, the operative turns the table round its axis K, K, so as to tumble it into the boxes below. The mud is in B; an impure schlich in B′, which must be washed again upon the *rack*; and a schlich fit for roasting in B″.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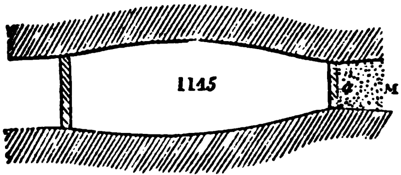
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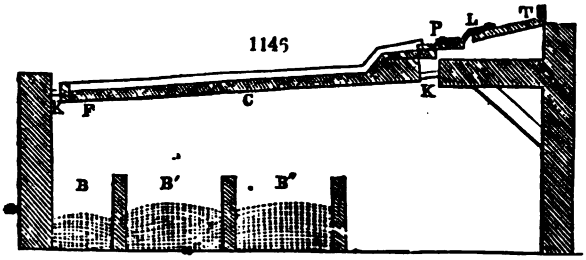
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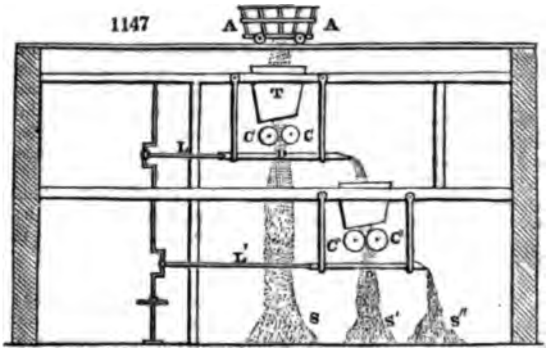
The slope of the rack-table for washing the *roasted* tin ore, is 7¾ inches in the nine feet.

Crushing rolls at the Pembroke mines.—Wagons, moved on a railway by an endless rope, bring the ore to be crushed immediately over the rolls, as shown in *fig.* 1147. A trap being opened in the side of the wagon, the ore falls into the hopper T, whence it passes directly between the twin cylinders C, C, and next upon the sieve D, which receives a seesaw motion horizontally, by means of the rod L, and the crank of the upright turning-shaft. The finer portion of ore, which passes through that sieve, forms the heap S. The coarser portion is tossed over the edge of the sieve, and falls between the cylinders C′ C′, upon a lower level, and forms the second heap S′ of sifted, and S″ of unsifted, ore.

The holes of the sieves D, D′, being of the same size, the products S, S′, are of the same fineness. S″ is ground again, being mixed, in the uppermost hopper T, along with the lumps from the wagons.

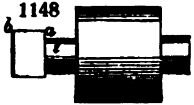
The diameter and length of the under rolls (see *fig*. 1148) are each 16 inches. *a b*, is the square end of the gudgeon *t*, which prevents the shaft shifting laterally out of its place. The diameter of the upper rolls is 18 inches, but their length is the same. Both are made of white cast iron, *chilled* or case hardened by being cast in iron moulds instead of sand; and they last a month, at least, when of good quality. They make from 10 to 15 turns in a minute, according to the hardness of the ores of tin or copper; and can grind about 50 tons of rich copper ore in 12 hours; but less of the poorer sort.

1147



The next process is the calcination in the *burning-house;* which includes several reverberatory furnaces. At the mine of Poldice, they are 4 or 5 yards long, by from 2½ to 3 yards wide. Their hearth is horizontal; the elevation, about 26 inches high near the fireplace, sinks slightly towards the chimney. There is but one opening, which is in the front; it is closed by a plate-iron door, turning on hinges. Above the door there is a chimney, to let the sulphurous and arsenical vapors fly off, which escape out of the hearth, without annoying the workmen. This chimney leads to horizontal flues, in which the arsenious acid is condensed.

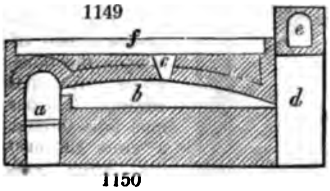
1148



Six hundred weights of ore are introduced; the calcination of which takes from 12 to 18 hours, according to the quantity of pyrites contained in the ore. At the beginning of the operation, a moderate heat is applied; after which it is pushed to a dull red, and kept so during several hours. The door is shut; the materials are stirred from time to time with an iron rake, to expose new surfaces, and prevent them from agglutinating or *kerning*, as the workmen say. The more pyrites is present, the more turning is necessary. Should the ore contain black oxyde of iron, it becomes peroxydized, and is then easily removed by a subsequent washing.

Figs. 1149, 1150 represent the furnace employed at Altenberg, in Saxony, for roasting tin ores. *a* is the grate; *b*, the sole of the roasting hearth; *c*, an opening in the arched roof for introducing the dried schlich (the ground and elutriated ore); *d*, is the smoke-mantle or chimney-hood, at the end of the furnace, under which the workmen turn over the spread schlich, with long iron rods bent at their ends; *e*, is the poison vent, which conducts the arsenical vapors to the poison chamber (*giftkaus*) of condensation.

1149



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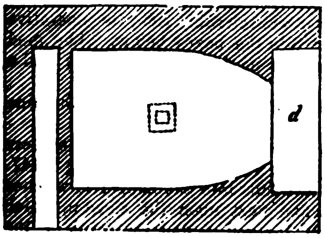


When the ore is sufficiently calcined, as is shown by its ceasing to exhale vapors, it is taken out, and exposed for some days to the action of the air, which decomposes the sulphurets, or changes them into sulphates. The ore is next put into a tub filled with water, stirred up with a wooden rake, and left to settle; by which means the sulphate of copper that may have been formed, is dissolved out. After some time, this water is drawn off into a large tank, and its copper recovered by precipitation with pieces of old iron. In this way, almost all the copper contained in the tin ore is extracted.

The calcined ore is sifted, and treated again on the racks, as above described. The pure schlich, called *black tin*, is sold under this name to the smelters; and that which collects on the middle part of the inclined wash-tables, being much mixed with wolfram, is called *mock lead*. This is passed once more through the stamps, and washed; when it also is sold as *black tin*.

Stream tin is dressed by similar methods; 1. by washing in a trunking-box, of such dimensions that the workman stands upon it in thick boots, and makes a skilful use of the rake; 2, by separating the larger conglomerate pebbles from the smaller pure ones; picking, stamping, and washing, on a kind of *sleeping-tables*. See **Metallurgy**, *figs*. 677, 678.

The tin ores of Cornwall and Devonshire are all reduced within the counties where they are mined, as the laws prohibit their exportation out of them. Private interests suffer no injury from this prohibition; because the vessels which bring the fuel from Wales, for smelting these ores, return to Swansea and Neath loaded with copper ores.

The smelting-works belong in general to individuals who possess no tin mines, but who purchase at the cheapest rate the ores from the mining proprietors. The ores are appraised according to their contents in metal, and its fineness; conditions which they determine by the following mode of assay:—When a certain number of bags of ore, of nearly the same quality, are brought to the works, a small sample is taken from each bag, and the whole are well blended. Two ounces of this average ore are mixed with about four per cent. of ground coal, put into an open earthen crucible, and heated in an air furnace (in area about ten inches square) till reduction takes place. As the furnace is very hot when the crucible is introduced, the assay is finished in about a quarter of an hour. The metal thus revived is poured into a mould, and what remains in the crucible is pounded in a mortar, that the grains of tin may be added to the ingot.

This method, though imperfect in a chemical point of view, serves the smelter's purpose, as it affords him a similar result to what he would get on the great scale. A more exact assay would be obtained by fusing, in a crucible lined with hard-rammed charcoal, the ore mixed with five per cent. of ground glass of borax. To the crucible a gentle heat should be applied during the first hour, then a strong heat during the second hour, and, lastly, an intense heat for a quarter of an hour. This process brings out from four to five per cent. more tin than the other; but it has the inconvenience of reducing the iron, should any be present; which by subsequent solution in nitric acid will be readily shown. This assay would be too tedious for the smelter, who may have occasion to try a great many samples in one day.

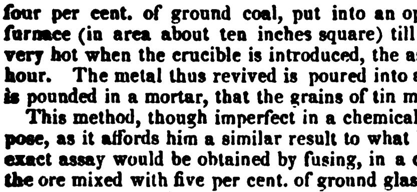
The smelting of tin ores is effected by two different methods:—

In the first, a mixture of the ore with charcoal is exposed to heat on the hearth of a reverberatory furnace fired with coal.

In the second, the tin ore is fused in a blast furnace, called a blowing-house, supplied with wood charcoal. This method is practised in only a few works, in order to obtain a very pure quality of tin, called *grain tin* in England, and *étain en larmes* in France; a metal required for certain arts, as dyeing, &c. This method is applied merely to stream tin.

In the *smelting-houses*, where the tin is worked in reverberatories, two kinds of furnaces are employed; the reduction and the refining furnaces.

Figs. 1151, 1152, represent the furnaces for smelting tin at St. Austle, in Cornwall; the former being a longitudinal section, the latter a ground plan. *a*, is the fire-door, through which pitcoal is laid upon the grate *b*; *c*, is the fire-bridge; *d*, the door for introducing the ore; *e*, the door through which the ore is worked upon the hearth *f*; *g*, the stoke-hole; *h*, an aperture in the vault or roof, which is opened at the discharge of the waste schlich, to secure the free escape of the fumes up the chimney; *i*, *i*, air channels for admitting cold air under the fire-bridge and the sole of the hearth, with the view of protecting them from injury by the intensity of the heat above. *k*, *k*, are basins into which the melted tin is drawn off; *l*, the flue; *m*, the chimney, from 35 to 50 feet high. The roasted and washed schlich is mixed with small coal or culm, along with a little slaked lime, or fluor spar, as a flux; each charge of ore amounts to from 15 to 24 cwts., and contains from 60 to 70 per cent. of metal.



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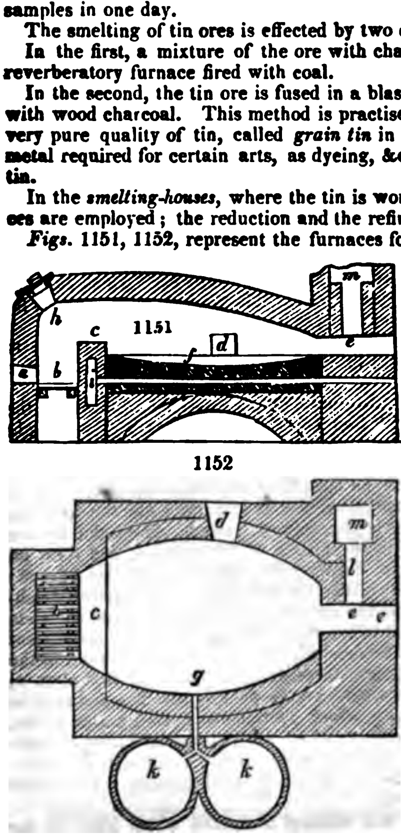
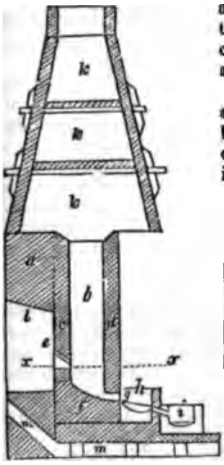


Fig. 1153 represents in a vertical section through the tuyère, and *fig*. 1154, in a horizontal section, in the dotted line *x*, *x*, of *fig*. 1153, the furnace employed for smelting tin at the Erzegebirge mines, in Saxony. *a*, are the furnace pillars, of gneiss; *b*, *b*, are shrouding or casing walls; *c*, the tuyère wall; *d*, front wall, both of granite; as also the tuyère *e*. *f*, the sole-stone, of granite, hewn out basin-shaped; *g*, the *eye*, through which the tin and slag are drawn off into the fore-hearth *h*; *i*, the stoke-hearth; *k*, *k*, the light ash chambers; *l*, the arch of the tuyère; *m*, *m*, the common flue, which is placed under the furnace and the hearths, and has its outlet under the vault of the tuyère.

1153



In the smelting furnaces at Geyer, the following dimensions are preferred:—Length of the tuyère wall, 11 inches; of the breast wall, 11 inches; depth of the furnace, 17 inches. High chimney-stalks are advantageous where a great quantity of ores is to be reduced, but not otherwise.

The *refining furnaces* are similar to those which serve for reducing the ore; only, instead of a basin of reception, they have a refining basin placed alongside, into which the tin is run. This basin is about four feet in diameter, and thirty-two inches deep; it consists of an iron pan, placed over a grate, in which a fire may be kindled. Above this pan there is a turning gib, by means of which a billet of wood may be thrust down into the bath of metal, and kept there by wheeling the gibbet over it, lowering a rod, and fixing it in that position.

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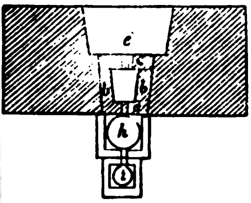


The works in which the blast furnaces are employed, are called *blowing-houses*. The smelting furnaces are six feet high, from the bottom of the crucible (concave hearth) to the throat, which is placed at the origin of a long and narrow chimney, interrupted by a chamber, where the metallic dust, carried off by the blast, is deposited. This chamber is not placed vertically over the furnace; but the lower portion of the chimney has an oblique direction from it. The furnace is lined with an upright cylinder of cast iron, coated internally with loam, with an opening in it for the blast. This opening, which corresponds to the lateral face opposite to the charging side, receives a *tuyère*, in which the nozzles of two cylinder single bellows, driven by a water-wheel, are planted. The *tuyère* opens at a small height above the sole of the furnace. On a level with the sole, the iron cylinder presents a slope, below which is the hemispherical basin of reception, set partly beneath the interior space of the furnace, and partly without. Near the corner of the building there is a second basin of reception, larger than the first, which can discharge itself into the former by a sloping gutter. Near this basin there is another, for the refining operation. These are all made either of brick or cast iron.

The quality of the average ground-tin ore prepared for smelting is such, that 20 parts of it yield from 12½ to 13 of metallic tin, (62½ to 65 per cent.) The treatment consists of two operations, *smelting* and *refining*.

First operation; deoxydization of the ore and fusion of the tin.—Before throwing the ore into the smelting furnace, it is mixed with from one fifth to one eighth of its weight of *blind coal*, in powder, called *culm*; and a little slaked lime is sometimes added, to render the ore more fusible. These matters are carefully blended, and damped with water, to render the charging easier, and to prevent the blast from sweeping any of it away at the commencement. From 12 to 16 cwts. are introduced at a charge; and the doors are immediately closed and luted, while the heat is progressively raised. Were the fire too strong at first, the tin oxyde would unite with the quartz of the gangue, and form an enamel. The heat is applied for 6 or 8 hours, during which the doors are not opened; of course the materials are not stirred. By this time the reduction is, in general, finished; the door of the furnace is removed, and the melted mass is worked up to complete the separation of the tin from the scoriæ, and to ascertain if the operation be in sufficient forwardness. When the reduction seems to be finished, the scoriæ are taken out at the same door, with an iron rake, and divided into three sorts; those of the first class A, which constitute at least three fourths of the whole, are as poor as possible, and may be thrown away; the scoriæ of the second class B, which contain some small grains of tin, are sent to the stamps; those of the third class C, which are last removed from the surface of the bath of tin, are set apart, and re-smelted, as containing a considerable quantity of metal in the form of grain tin. These scoriæ are in small quantity. The stamp slag contains fully five per cent. of metallic tin.

As soon as the scoriæ are cleared away, the channel is opened which leads to the basin of reception, into which the tin consequently flows out. Here it is left for some time, that the scoriæ which may be still mixed with the metal, may separate, in virtue of the difference of their specific gravities. When the tin has sufficiently settled, it is lifted out with ladles, and poured into cast-iron moulds, in each of which a bit of wood is fixed, to form a hole in the ingot, for the purpose of drawing it out when it becomes cold.

Refining of tin.—The object of this operation is to separate from the tin, as completely as possible, the metals reduced and alloyed along with it. These are, principally, iron, copper, arsenic, and tungsten; to which are joined, in small quantities, some sulphurets and arseniurets that have escaped decomposition, a little unreduced oxyde of tin, and also some earthy matters which have not passed off with the scoriæ.

Liquation.—The refining of tin consists of two operations; the first being a liquation, which, in the interior, is effected in a reverberatory furnace, similar to that employed in smelting the ore, (*figs.* 1151, 1152.) The blocks being arranged on the hearth of the furnace, near the bridge, are moderately heated; the tin melts, and flows away into the refining-basin; but, after a certain time, the blocks cease to afford tin, and leave on the hearth a residuum, consisting of a very ferruginous alloy.

Fresh tin blocks are now arranged on the remains of the first; and thus the liquation is continued till the refining-basin be sufficiently full, when it contains about five tons. The residuums are set aside, to be treated as shall be presently pointed out.

Refining proper.—Now begins the second part of the process. Into the tin-bath, billets of green wood are plunged, by aid of the gibbet above described. The disengagement of gas from the green wood produces a constant ebullition in the tin; bringing up to its surface a species of froth, and causing the impurest and densest parts to fall to the bottom. That froth, composed almost wholly of the oxydes of tin and foreign metals, is successively skimmed off, and thrown back into the furnace. When it is judged that the tin has boiled long enough, the green wood is lifted out, and the bath is allowed to settle. It separates into different zones, the upper being the purest; those of the middle are charged with a little of the foreign metals; and the lower are much contaminated with them. When the tin begins to cool, and when a more complete separation of its different qualities cannot be looked for, it is lifted out in ladles, and poured into cast-iron moulds. It is obvious, that the order in which the successive blocks are obtained, is that of their purity; those formed from the bottom of the basin being usually so impure, that they must be subjected anew to the refining process, as if they had been directly smelted from the ore.

The refining operation takes 5 or 6 hours; namely, an hour to fill the basin, three hours to boil the tin with the green wood, and from one to two hours for the subsidence.

Sometimes a simpler operation, called *tossing*, is substituted for the above artificial ebullition. To effect it, a workman lifts some tin in a ladle, and lets it fall back into the boiler, from a considerable height, so as to agitate the whole mass. He continues this manipulation for a certain time; after which, he skims with care the surface of the bath. The tin is afterwards poured into moulds, unless it be still impure. In this case, the separation of the metals is completed by keeping the tin in a fused state in the boiler for a certain period, without agitation; whereby the upper portion of the bath (at least one half) is pure enough for the market.

The moulds into which the tin blocks are cast, are usually made of granite. Their capacity is such, that each block shall weigh a little more than three hundred weights. This metal is called block tin. The law requires them to be stamped or *coined* by public officers, before being exposed to sale. The purest block tin is called refined tin.

The treatment just detailed gives rise to two stanniferous residuums, which have to be smelted again. These are—

1. The scoriæ B and C, which contain some granulated particles of tin.
2. The dross found on the bottom of the reverberatory furnace, after re-melting the tin to refine it.

The scoriæ C, are smelted without any preparation; but those marked B, are stamped in the mill, and washed, to concentrate the tin grains; and from this rich mixture, called *prillion*, smelted by itself, a tin is procured of very inferior quality. This may be readily imagined, since the metal which forms these granulations is what, being less fusible than the pure tin, solidified quickly, and could not flow off into the metallic bath.

Whenever all the tin blocks have thoroughly undergone the process of liquation, the fire is increased, to melt the less fusible residuary alloy of tin with iron and some other metals, and this is run out into a small basin, totally distinct from the refining basin. After this alloy has reposed for some time, the upper portion is lifted out into block moulds, as impure tin, which needs to be refined anew. On the bottom and sides of the basin there is deposited a white, brittle alloy, with a crystalline fracture, which contains so great a proportion of foreign metals, that no use can be made of it. About three and a half tons of coal are consumed in producing 2 of tin.

Smelting of tin by the blast furnace.—This mode of reduction employs only wood charcoal, and its object is to obtain tin of the maximum purity to which it can be brought by manufacturing processes. The better ores of the stream-works, and the finer tin sands, are selected for this operation. The washings being always well performed, the oxyde of tin is exempt from every arsenical or sulphurous impurity, and is associated with nothing but a little hematite. It is therefore never calcined.

The smelting is effected without addition; only, in a few cases, some of the residuary matters of a former operation are added to the ore. About a ton and six tenths of wood charcoal are burned for one ton of fine smelted tin. The only rule is, to keep the furnace always full of charcoal and ore. The revived tin is received immediately in the first basin; then run off into the second, where it is allowed to settle for some time. The scoriæ that run off into the first basin, are removed as soon as they fix. These scoriæ are divided into two classes; namely, such as still retain tin oxyde, and such as hold none of the metal in that state, but only in granulations. The metallic bath is divided, by repose, into horizontal zones, of different degrees of purity; the more compound and denser matters falling naturally to the bottom of the basin. The tin which forms the superior zones, being judged to be pure enough, is transvased by ladles into the refining basin, previously heated, and under which, if it is of cast-iron, a moderate fire is applied. The tin near the bottom of the receiving basin is always laded out apart, to be again smelted; sometimes, indeed, when the furnace is turning out very impure tin, none of it is transvased into the second basin; but the whole is cast into moulds, to be again treated in the blast furnace.

In general they receive no other preparation, but the green wood ebullition, before passing into the market. Sometimes, however, the block of metal is heated till it becomes brittle, when it is lifted to a considerable height, and let fall, by which it is broken to pieces, and presents an agglomeration of elongated grains or *tears*; whence it is called *grain tin*.

On making a comparative estimate of the expense by the *blowing-house* process, and by the reverberatory furnace, it has been found that the former yields about 66 per cent. of tin, in smelting the stream or alluvial ore, whose absolute contents are from 75 to 78 parts of metal in the hundred. One ton of tin consumes a ton and six tenths of wood charcoal, and suffers a loss of 15 per cent. In working with the reverberatory furnace, it is calculated that ore whose mean contents by an exact analysis are 70 per cent., yields 65 per cent. on the great scale. The average value of tin ore, as sold to the smelter, is 50 pounds sterling per ton; but it fluctuates, of course, with the market prices. In 1824, the ore of inferior quality cost 30*l.*, while the purest sold for 60*l.* One ton of tin, obtained from the reverberatory furnace, cost—

1½ tons of ore, worth - - - - - - -	£75	0	0
1¾ tons of coals, at 10*s.* per ton - - - - -	0	17	6
Wages of labor, interest on capital, &c. - - - -	3	0	0
	78	17	6

On comparing these results with the former, we perceive that in a *blowing-house* the loss of tin is 15 per cent., whereas it is only 5 in the reverberatory furnace. The expense in fuel is likewise much less relatively in the latter process; for only 1¾ tons of coals are consumed for one ton of tin; while a ton and six tenths of wood charcoal are burned to obtain the same quantity of tin in the blowing-house; and it is admitted that one ton of wood charcoal is equivalent to two tons of coal, in calorific effect. Hence every thing conspires to turn the balance in favor of the reverberatory plan. The operation is also, in this way, much simpler, and may be carried on by itself. The scoriæ, besides, from the reverberatory hearth, contain less tin than those derived from the same ores treated with charcoal by the blast, as is done at Altenberg. It must be remembered, however, that the grain tin procured by the charcoal process is reckoned to be finer, and fetches a higher price; a superiority partly due to the purity of the ore reduced, and partly to the purity of the fuel.

To test the quality of tin, dissolve a certain weight of it with heat in muriatic acid; should it contain arsenic, brown-black flocks will be separated during the solution, and arseniureted hydrogen gas will be disengaged, which, on being burned at a jet, will deposite the usual gray film of metallic arsenic upon a white saucer held a little way above the flame. Other metals present in the tin are to be sought for, by treating the above solution with nitric acid of spec. grav. 1·16, first in the cold, and at last with heat and a small excess of acid. When the action is over, the supernatant liquid is to be decanted off the peroxydized tin, which is to be washed with very dilute nitric acid, and both liquors are to be evaporated to dissipate the acid excess. If, on the addition of water to the concentrated liquor, a white powder falls, it is a proof that the tin contains bismuth; if on adding sulphate of ammonia, a white precipitate appears, the tin contains lead; water of ammonia added to supersaturation, will occasion reddish-brown flocks, if iron is present; and on evaporating the supernatant liquid to dryness, the copper will be obtained.

The uses of tin are very numerous. Combined with copper, in different proportions, it forms bronze, and a series of other useful alloys; for an account of which see COPPER. With iron, it forms tin-plate; with lead, it constitutes pewter, and solder of various kinds. (See LEAD.) Tin-foil coated with quicksilver makes the reflecting surface of glass mirrors. (See GLASS.) Nitrate of tin affords the basis of the scarlet dye on wool, and of many bright colors to the calico-printer and the cotton-dyer. (See SCARLET and TIN MORDANTS.) A compound of tin with gold gives the fine crimson and purple colors to stained glass and artificial gems. (See PURPLE OF CASSIUS.) Enamel is made by fusing oxyde of tin with the materials of flint glass. This oxyde is also an ingredient in the white and yellow glazes of pottery-ware.

AN ACCOUNT of TIN coined in Cornwall and Devon, from 1817 to 1829, inclusive:—

Years.	Blocks.	Tons.	Years.	Blocks.	Tons.
1817	25,379	4,120	1824	28,602	4,819
1818	23,048	3,745½	1825	24,902	4,170
1819	18,881	3,065	1826	26,299	4,406
1820	17,084	2,773½	1827	31,744	5,316
1821	19,273	3,128	1828	28,179	4,696
1822	18,732	3,137	1829	26,344	4,396
1823	24,077	4,031			

Tin imported. Duty, 50*s*. per cwt.		Tin exported.	Tin imported. Duty, 50*s*. per cwt		Tin exported.
	Cwts.	*Cwts.*		*Cwts.*	*Cwts.*
1827	2,217	2,938	1832	29,203	21,720
1828	3,386	3,258	1833	35,124	39,850
1829	2,674	2,581	1834	46,769	46,685
1830	15,539	10,426	1835	17,705	23,796
1831	8,099	12,226	1836	23,236	17,231

The principal importations are from the East India Company's territories and Ceylon: they amounted in 1832 to 24,585 cwts.; in 1833 to 27,928; in 1834 to 33,611; in 1835 to 10,104; and in 1836 to 17,729. From Sumatra and Java 1961 cwts. were imported in 1832, and 1145 in 1834, but in the other years greatly less.

Declared value of tin and pewter wares and tin-plates exported in—	1827. 302,255*l.*	1829. 235,178*l.*	1831. 239,143*l.*	1833. 282,176*l.*	1835. 381,076*l.*
	1828. 266,651*l.*	1830. 249,657*l.*	1832. 243,259*l.*	1834. 337,056*l.*	1836. 387,951*l.*

Of these goods, from two fifths to three fifths go to the United States of America.

ABSTRACT of TIN coined in Cornwall and Devon, in the year ending June 30, 1835; from the *Mining Review*, vol. iii.

Smelters.	Blocks of Grain Tin.		Blocks of Common Tin.		Totals.	
	1834.	1835.	1834.	1835.	1834.	1835.
Daubuz and Co. - - - - -	728	875	6114	4494	6842	5369
Grenfell and Boase - - -	344	196	3776	3097	4120	3293
Bolitho and Sons - - - - -	229	153	3829	3099	4058	3252
R. and J. Michell - - -	101	75	709	575	810	650
Wheal Vor Adventurers - - -	—	—	3925	4069	3925	4069
Taylor, Sons and Co. - - -	—	112	—	1250	—	1362
John Batten and Son - - -	28	49	2352	2351	2380	2400
Joseph Carne - - - - -	—	—	896	851	896	851
William Cornish - - - - -	—	—	622	574	622	574
Gill and Co. (at Morwelham) -	—	—	758	—	758	—
Ditto (at Calstock) - -	60	—	605	—	665	—
Rundle, Paul and Co. - - -	—	12	—	1545	—	1557
Total - - - -	1490	1472	23586	21905	25076	23377

Total, in 1834, 4180 tons; in 1835, 3899 tons. (6 blocks = 1 ton.)

TINCAL, crude borax.

TINCTORIAL MATTER. One of the most curious and valuable facts ascertained upon this subject, is, that madder kept in casks, in a warm place, undergoes a species of fermentation, which, by ripening, or rather deoxydizing the coloring-matter, increases its dyeing power by no less than from 20 to 50 per cent. See M. H. Schlumberger's memoir read to the *Société Industrielle de Mulhausen*, 24 November, 1837.

TINCTURE is a title used by apothecaries to designate alcohol, in a somewhat dilute state, impregnated with the active principles of either vegetable or animal substances.

TIN-GLASS is a name of bismuth.

TIN MORDANTS, for dyeing scarlet:—

Mordant A, as commonly made by the dyers, is composed of 8 parts of aquafortis, 1 part of common salt or sal ammoniac, and 1 of granulated tin. This preparation is very uncertain.

Mordant B.—Pour into a glass globe, with a long neck, 3 parts of pure nitric acid at 30° B.; and 1 part of muriatic acid at 17°; shake the globe gently, avoiding the corrosive vapors, and put a loose stopper in its mouth. Throw into this nitro-muriatic acid one eighth of its weight of pure tin, in small bits at a time. When the solution is complete, and settled, decant it into bottles, and close them with ground stoppers. It should be diluted only when about to be used.

Mordant C, by Dambourney.—In two drachms Fr. (144 grs.) of pure muriatic acid, dissolve 18 grains of Malacca tin. This is reckoned a good mordant for brightening or fixing the color of peachwood.

Mordant D, by Hellot.—Take 8 ounces of nitric acid, diluted with as much water; dissolve in it half an ounce of sal ammoniac, and 2 drachms of nitre. In this acid solution dissolve one ounce of granulated tin of Cornwall, observing not to put in a fresh piece till the preceding be dissolved.

Mordant E, by Scheffer.—Dissolve one part of tin in four of a nitro-muriatic acid, prepared with nitric acid diluted with its own weight of water, and one thirty-secondth of sal ammoniac.

Mordant F, by Poerner.—Mix one pound of nitric acid with one pound of water, and dissolve in it an ounce and a half of sal ammoniac. Stir it well, and add, by very slow degrees, two ounces of tin turned into thin ribands upon the lathe.

Mordant G, by Berthollet.—Dissolve in nitric acid of 30° B. one eighth of its weight of sal ammoniac, then add by degrees one eighth of its weight of tin, and dilute the solution with one fourth of its weight of water.

Mordant K, by Dambourney.—In one drachm (72 grs.) of muriatic acid at 17°, one of nitric acid at 30°, and 18 grains of water, dissolve, slowly and with some heat, 18 grains of fine Malacca tin.

Mordant L is the birch bark prescribed by Dambourney.—This bark, dried and ground, is said to be a very valuable substance for fixing the otherwise fugitive colors produced by woods, roots, archil, &c.

TIN-PLATE. The only alloy of iron interesting to the arts is that with tin, in the formation of *tin-plate* or *white-iron*.

The sheet iron intended for this manufacture is refined with charcoal instead of coke, subsequently rolled to various degrees of thinness, and cut into rectangles of different sizes, by means of a shearing-machine driven by a water-wheel, which will turn out 100 boxes a day, or four times the number cut by hand labor. The first step towards tinning is to free the metallic surface from every particle of oxyde or impurity, for any such would inevitably prevent the iron from alloying with the tin. The plates are next bent separately by hand into a saddle or Λ shape, and ranged in a reverberatory oven, so that the flame may play freely among them, and heat them to redness. They are then plunged into a bath, composed of four pounds of muriatic acid diluted with three gallons of water, for a few minutes, taken out and drained on the floor, and once more exposed to ignition in a furnace, whereby they are *scaled*, that is to say, cast their scales. The above bath will suffice for scaling 1800 plates. When taken out, they are beat level and smooth on a cast-iron block, after which they appear mottled blue and white, if the *scaling* has been thoroughly done. They are next passed through *chilled* rolls or cast-iron cylinders, rendered very hard by being cast in thick iron moulds, as has been long practised by the Scotch founders in casting bushes for cart-wheels. After this process of *cold rolling*, the plates are immersed, for ten or twelve hours, in an acidulous ley, made by fermenting bran-water, taking care to set them separately on edge, and to turn them at least once, so that each may receive a due share of the operation. From this ley-steep they are transferred into a leaden trough, divided by partitions, and charged with dilute sulphuric acid. Each compartment is called a *hole* by the workmen, and is calculated to receive about 225 plates, the number afterwards packed up together in a box. In this liquid they are agitated about an hour, till they become perfectly bright, and free from such black spots as might stain their surface at the time of immersion. This process, called pickling, is both delicate and disagreeable, requiring a good workman, at high wages. The temperature of the last two steeps should be at least 90° or 100° F., which is kept up by stoves in the apartments. The plates are finally scoured with hemp and sand in a body of water, and then put aside for use in a vessel of pure water, under which they remain bright and free from rust for many months, a very remarkable circumstance.

The *tinning* follows these preparatory steps. A range of rectangular cast-iron pots is set over a fire-flue in an apartment called the *stow*, the workmen stationing themselves opposite to the narrow ends. The first rectangle in the range is the tin-pot; the second is the wash-pot, with a partition in it; the third is the grease-pot; the fourth is the pan, grated at bottom; the fifth is the list-pot, and is greatly narrower than any of the rest: they are all of the same length.

The prepared plates, dried by rubbing bran upon them, are first immersed one by one in a pot filled with melted tallow alone, and are left there for nearly an hour. They are thence removed, with the adhering grease, into pot No. 1, filled with a melted mixture of block and grain tin, covered with about four inches of tallow, slightly carbonized. This pot is heated by a fire, playing under its bottom and round its sides, till the metal becomes so hot as nearly to inflame the grease. Here about 340 plates are exposed, upright, to the action of the tin for an hour and a half, or more, according to their thickness. They are next lifted out, and placed upon an iron grating, to let the superfluous metal drain off; but this is more completely removed in the next process, called *washing*.

Into the wash-pot No. 2, filled with melted *grain* tin, the workman puts the above plates, where the heat detaches the ribs, and drops. There is a longitudinal partition in it, for keeping the drop of tin that rises in washing from entering the vessel where the last dip is given. Indeed, the metal in the wash-pot, after having acted on 60 or 70 boxes, becomes so foul, that the weight of a block (300 cwts.) of it is transferred into the tin-pot, No. 1, and replaced by a fresh block of grain tin. The plates being lifted out of the wash-pot, with tongs held in the left hand of the workman, are scrubbed on each side with a peculiar hempen brush, held in his right hand, then dipped for a moment in the hot tin, and forthwith immersed in the adjoining grease-pot, No. 3. This requires manual dexterity; and though only three-pence be paid for brushing and tin-washing 225 plates, yet a good workman can earn six shillings and three-pence in twelve hours, by putting 5625 plates through his hands. The final tin-dip is useful to remove the marks of the brush, and to make the surface uniformly bright. To regulate the temperature of the tallow-pot, and time during which the plates are left in it, requires great skill and circumspection on the part of the workman. If kept in it too long, they would be deprived, to a certain extent, of their silvery lustre; and if too short, streaks of tin would disfigure their surface. As a thick plate retains more heat after being lifted out of the washing-pot, it requires a proportionally cooler grease-pot. This pot has pins fixed within it, to keep the plates asunder; and whenever the workman has transferred five plates to it, a boy lifts the first out into the cold adjoining pan, No. 4; as soon as the workman transfers a sixth plate, the boy removes the second; and so on. The manufacture is completed by removing the wire of tin left on the under edge of the plates, in consequence of their vertical position in the preceding operations. This is the business of the *list-boy*, who seizes the plates when they are cool enough to handle, and puts the lower edge of each, one by one, into the list-pot, No. 5, which contains a very little melted tin, not exceeding a quarter of an inch in depth. When he observes the wire-edge to be melted, he takes out the plate, and, striking it smartly with a thin stick, detaches the superfluous metal, which leaves merely a faint stripe where it lay. This mark may be perceived on every tin-plate in the market.

The plates are finally prepared for packing up in their boxes, by being well cleansed from the tallow, by friction with bran.

Mr. Thomas Morgan obtained a patent, in September, 1829, for clearing the sheet-iron plates with dilute sulphuric acid in a *hole*, instead of *scaling* them in the usual way, previous to their being cold rolled, annealed, and tinned; whereby, he says, a better article is produced at a cheaper rate.

Crystallized tin-plate, see Moiree Metallique. It would seem that the acid merely lays bare the crystalline structure really present on every sheet, but masked by a film of redundant tin. Though this showy article has become of late years vulgarized by its cheapness, it is still interesting in the eyes of the practical chemist. The English tin-plates marked F answer well for producing the *Moirée*, by the following process. Place the tin-plate, slightly heated, over a tub of water, and rub its surface with a sponge dipped in a liquor composed of four parts of aquafortis, and two of distilled water, holding one part of common salt or sal ammoniac in solution. Whenever the crystalline spangles seem to be thoroughly brought out, the plate must be immersed in water, washed either with a feather or a little cotton (taking care not to rub off the film of tin that forms the feathering), forthwith dried with a low heat, and coated with a lacker varnish, otherwise it loses its lustre in the air. If the whole surface is not plunged at once in cold water, but if it be partially cooled by sprinkling water on it, the crystallization will be finely variegated with large and small figures. Similar results will be obtained by blowing cold air through a pipe on the tinned surface, while it is just passing from the fused to the solid state; or a variety of delineations may be traced, by playing over the surface of the plate with the pointed flame of a blowpipe.

The following Table shows the several sizes of tin-plates, the marks by which they are distinguished, and their current wholesale prices in London:—

Names.	Sizes.	No. in a box.	Weight of each box.	Marks on the boxes.	Prices per box, in		
					1823.		1838.
	Inches.		*cwt. qrs. lbs.*		*s.*		*s. d.*
Common, No. 1 -	13¾ by 10	225	1 0 0	CI.	47		35
Ditto 2 -	13¼ — 9¼	-	0 3 21	CII.	45		33 6
Ditto 3 -	12¾ — 9½	-	0 3 16	CIII.	43		32 9
Cross, No. 1 -	13¾ — 10	-	1 1 0	XI.	53		40 2
Two crosses, 1 -	-	-	1 1 21	XXI.	58		43 2
Three crosses, 1 -	-	-	1 2 14	XXX. I.	63		47
Four crosses, 1 -	-	-	1 3 7	XXXX. I.			
Common doubles -	16¾ — 12½	100	0 3 21	CD.	64–6	150 sheets in each.	48 6
Cross doubles -	-	-	1 0 14	XD.	73–6		56
Two cross do. -	-	-	1 1 7	XXD.	81		60 6
Three cross do. -	-	-	1 2 0	XXXD.	88–6		65
Four cross do. -	-	-	1 2 21	XXXXD.			
Com. small doubles -	5 — 11	200	1 2 0	CSD.	69		51 6
Cross do. do. -	-	-	1 2 21	XSD.	75		56 0
Two cross do. -	-	-	1 3 14	XXSD.	80		59 6
Three do. do. -	-	-	2 0 7	XXXSD.			
Four do. do. -	-	-	2 1 0	XXXXSD.			
Waster's com. No. 1	3¾ — 10	225	1 0 0	WCI.	44		32 9
Ditto cross, 1	ditto	-	1 1 0	WXI.	50		47 3

These are the cash prices of one wholesale warehouse in Thames street; an immediately adjoining warehouse charges fully *1s.* more upon the standard CI, and proportionally upon the others.

TITANIUM is a rare metal, discovered by Klaproth, in menachanite, in 1794. It has been detected since in the form of small cubes of a copper-red color, in some of the blast furnaces in Yorkshire. According to Hassenfratz, its presence in small quantity does not impair the malleability of iron. It is very brittle, so hard as to scratch steel, and very light, having a specific gravity of only 5·3. It will not melt in the heat of any furnace, nor dissolve, when crystallized, even in nitro-muriatic acid; but only when in the powder. By calcination with nitre, it becomes oxygenated, and forms titanate of potash. Traces of this metal may be detected in many irons, both wrought and cast. The principal ores of titanium are *sphene*, common and foliated, *rutile*, *iserine*, *menachanite*, and *octahedrite* or *pyramidal titanium ore*. None of them has been hitherto applied to any use.

TOBACCO. It is said that the name tobacco was given by the Spaniards to the plant, because it was first observed by them at Tabasco, or Tabaco, a province of Yucatan in Mexico. In 1560, Nicot, the French ambassador to Portugal, having received some tobacco from a Flemish merchant, showed it, on his arrival in Lisbon, to the grand prior, and, on his return into France, to Catherine of Medicis, whence it has been called Nicotiana by the botanists. Admiral Sir Francis Drake, having, on his way home from the Spanish Main in 1586, touched at Virginia, and brought away some forlorn colonists, is reported to have first imported tobacco into England. But, according to Lobel, this plant was cultivated in Britain before the year 1570; and was consumed by smoking in pipes by Sir Walter Raleigh and companions, so early as the year 1584.

The plants are hung up to dry during four or five weeks; taken down out of the sheds in damp weather, for in dry they would be apt to crumble into pieces; stratified in heaps, covered up, and left to sweat for a week or two, according to their quality and the state of the season; during which time they must be examined frequently, opened up, and turned over, lest they become too hot, take fire, or run into putrefactive fermentation. This process needs to be conducted by skilful and attentive operatives. An experienced negro can form a sufficiently accurate judgment of the temperature, by thrusting his hand down into the heap.

The tobacco thus prepared, or often without fermentation, is sent into the market; but, before being sold, it must undergo the inspection of officers, appointed by the state with very liberal salaries, who determine its quality, and brand an appropriate stamp upon its casks, if it be sound; but if it be bad, it is burned.

Our respectable tobacconists are very careful to separate all the damaged leaves, before they proceed to their preparation, which they do by spreading them in a heap upon a stone pavement, watering each layer in succession with a solution of sea salt, of spec. grav. 1·107, called *sauce*, till a ton or more be laid; and leaving their principles to react on each other for three or four days, according to the temperature, and the nature of the tobacco. It is highly probable that ammonia is the volatilizing agent of many odors, and especially of those of tobacco and musk. If a fresh green leaf of tobacco be crushed between the fingers, it emits merely the herbaceous smell common to many plants; but if it be triturated in a mortar, along with a little quicklime or caustic potash, it will immediately exhale the peculiar odor of snuff. Now analysis shows the presence of muriate of ammonia in this plant, and fermentation serves further to generate free ammonia in it; whence, by means of this process, and lime, the odoriferous vehicle is abundantly developed. If, on the other hand, the excess of alkaline matter in the tobacco of the shops be saturated by a mild dry acid, as the tartaric, its peculiar aroma will entirely disappear.

Tobacco contains a great quantity of an azotized principle, which by fermentation produces abundance of ammonia; the first portions of which saturate the acid juices of the plant, and the rest serve to volatilize its odorous principles. The salt water is useful chiefly in moderating the fermentation, and preventing it from passing into the putrefactive stage; just as salt is sometimes added to saccharine worts in tropical countries, to temper the fermentative action. The sea salt, or concentrated sea water, which contains some muriate of lime, tends to keep the tobacco moist, and is therefore preferable to pure chloride of sodium for this purpose. Some tobacconists mix molasses with the salt *sauce*, and ascribe to this addition the violet color of the *macouba* snuff of Martinique; and others add a solution of extract of liquorice. The following prescription is that used by a skilful manufacturer:—In a solution of the liquorice juice, a few figs are to be boiled for a couple of hours; to the decoction, while hot, a few bruised anise-seeds are to be added, and when cold, common salt to saturation. A little silent spirit of wine being poured in, the mixture is to be equably, but sparingly, sprinkled with the rose of a watering-pot, over the leaves of the tobacco, as they are successively stratified upon the preparation floor.

The fermented leaves, being next stripped of their middle ribs by the hands of children, are sorted anew, and the large ones are set apart for making cigars. Most of the tobaccos on sale in our shops are mixtures of different growths: one kind of smoking tobacco, for example, consists of 70 parts of Maryland, and 30 of meager Virginia; and one kind of snuff consists of 80 parts of Virginia, and 30 parts of either Humesfort or Warwick. The Maryland is a very light tobacco, in thin yellow leaves; that of Virginia is in large brown leaves, unctuous or somewhat gluey on the surface, having a smell somewhat like the figs of Malaga; that of Havana is in brownish, light leaves, of an agreeable and rather spicy smell; it forms the best cigars. The Carolina tobacco is less unctuous than the Virginian; but in the United States it ranks next to the Maryland.

The shag tobacco is dried to the proper point upon sheets of copper.

Tobacco is cut into what is called shag tobacco by knife-edged chopping stamps, a machine somewhat similar to that represented under METALLURGY, *fig.* 670. For grinding the tobacco leaves into snuff, conical mortars are employed, somewhat like that used by the Hindoos for grinding sugar-canes, *fig.* 1080; but the sides of the snuff-mill have sharp ridges from the top to near the bottom.

Mr. L. W. Wright obtained a patent in August, 1827, for a tobacco-cutting machine, which bears a close resemblance to the well-known machines with revolving knives, for cutting straw into chaff. The tobacco, after being squeezed into cakes, is placed upon a smooth bed within a horizontal trough, and pressed by a follower and screws to keep it compact. These cakes are progressively advanced upon the bed, or fed in, to meet the revolving blades. The speed of the feeding-screw determines the degree of fineness of the sections or particles into which the tobacco is cut.

I was employed some years ago by the Excise to analyze a quantity of snuff, seized on suspicion of having been adulterated by the manufacturer. I found it to be largely drugged with pearl-ashes, and to be thereby rendered very pungent, and absorbent of moisture; an economical method of rendering an effete article at the same time active and aqueous.

According to the recent analysis of Possett and Reimann, 10,000 parts of tobacco-leaves contain — 6 of the peculiar chemical principle *nicotine*; 1. of *nicotianine*; 287 of slightly bitter extractive; 174 of gum, mixed with a little malic acid; 26·7 of a green resin; 26 of vegetable albumen; 104·8 of a substance analogous to gluten; 51 of malic acid; 12 of malate of ammonia; 4·8 of sulphate of potassa; 6·3 of chloride of potassium; 9·5 of potassa, which had been combined with malic and nitric acids; 16·6 of phosphate of lime; 24·2 of lime, which had been combined with malic acid; 8·8 of silica; 496·9 of fibrous or ligneous matter; traces of starch; and 88·28 of water.

Nicotine is a transparent colorless liquid, of an alkaline nature. It may be distilled in a retort plunged into a bath heated to 290° Fahrenheit. It has a pricking, burning taste, which is very durable; and a pungent, disagreeable smell. It burns by means of a wick, with the diffusion of a vivid light, and much smoke. It may be mixed with water in all proportions. It is soluble also in acetic acid, oil of almonds, alcohol, and ether, but not in oil of turpentine. It acts upon the animal economy with extreme violence; and in the dose of one drop it kills a dog. It forms salts with the acids. About one part of it may be obtained by very skilful treatment from one thousand of good tobacco.

Tobacco imported into the United Kingdom, viz. — unmanufactured, in 1836, 52,232,907 lbs.; in 1837, 27,070,448 lbs.; — manufactured, and snuff, in 1836, 182,248 lbs.; in 1837, 612,287 lbs. Retained for home consumption, unmanufactured, in 1836, 22,309,021 lbs.; in 1837, 22,504,343 lbs.;—manufactured, and snuff, in 1836, 159,226 lbs.; in 1837, 145,045 lbs. Duty received,—on unmanufactured tobacco, in 1836, £3,344,703; in 1837, £3,375,125; on manufactured tobacco, and snuff, in 1836, £71,560; in 1837, £65,220.

TOBACCO-PIPES. The practice of smoking tobacco has become so general in many nations as to render the manufacture of tobacco-pipes a considerable branch of industry. Some seek in the inhalation of tobacco-smoke a pleasurable narcotism; others imagine it to be beneficial to their health; but, in general, smoking is merely a dreamy resource against ennui, which ere long becomes an indispensable stimulus. The filthiness of this habit, the offensive odor which persons under its influence emit from their mouths and clothes, the stupor it too often occasions, as well as the sallow complexion, black or carious teeth, and impaired digestion, all prove the great consumption of tobacco to be akin in evil influence upon mankind to the use of ardent spirits.

Tobacco-pipes are made of a fine-grained plastic white clay, to which they have given the name. It is worked with water into a thin paste, which is allowed to settle in pits, or it may be passed through a sieve, to separate the silicious or other stony impurities; the water is afterwards evaporated till the clay becomes of a doughy consistence, when it must be well kneaded to make it uniform. Pipe-clay is found chiefly in the isle of Purbeck and Dorsetshire. It is distinguished by its perfectly white color, and its great adhesion to the tongue after it is baked; owing to the large proportion of alumina which it contains.

A child fashions a ball of clay from the heap, rolls it out into a slender cylinder upon a plank, with the palms of his hands, in order to form the stem of the pipe. He sticks a small lump to the end of the cylinder for forming the bowl; which having done, he lays the pieces aside for a day or two, to get more consistence. In proportion as he makes these rough figures, he arranges them by dozens on a board, and hands them to the pipemaker.

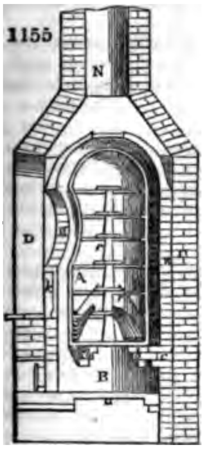
The pipe is finished by means of a folding brass or iron mould, channelled inside of the shape of the stem and the bowl, and capable of being opened at the two ends. It is formed of two pieces, each hollowed out like a half-pipe, cut as it were lengthwise; and these two jaws, when brought together, constitute the exact space for making one pipe. There are small pins in one side of the mould, corresponding to holes in the other, which serve as guides for applying the two together with precision.

The workman takes a long iron wire, with its end oiled, and pushes it through the soft clay in the direction of the stem, to form the bore, and he directs the wire by feeling with his left hand the progress of its point. He lays the pipe in the groove of one of the jaws of the mould, with the wire sticking in it; applies the other jaw, brings them smartly together, and unites them by a clamp or vice, which produces the external form. A lever is now brought down, which presses an oiled stopper into the bowl of the pipe, while it is in the mould, forcing it sufficiently down to form the cavity; the wire being meanwhile thrust backwards and forwards so as to pierce the tube completely through. The wire must become visible at the bottom of the bowl, otherwise the pipe will be imperfect. The wire is now withdrawn, the jaws of the mould opened, the pipe taken out, and the redundant clay removed with a knife. After drying for a day or two, the pipes are scraped, polished with a piece of hard wood, and the stems being beat into the desired form, they are carried to the baking kiln, which is capable of firing fifty gross in from 8 to 12 hours. A workman and a child can easily make five gross of pipes in a day.

No tobacco-pipes are so highly prized as those made in Natolia, in Turkey, out of meerschaum, a somewhat plastic magnesian stone, of a soft greasy feel, which is formed into pipes after having been softened with water. It becomes white and hard in the kiln.

A tobacco-pipe kiln should diffuse an equal heat to every part of its interior, while it excludes the smoke of the fire. The crucible, or large sagger, A, A, *figs.* 1155 and 1156, is a cylinder, covered in with a dome. It is placed over the fireplace B, and enclosed within a furnace of ordinary brickwork D, D, lined with fire-bricks E, E. Between this lining and the cylinder, a space of about 4 inches all round is left for the circulation of the flame. There are 12 supports or ribs between the cylinder and the furnace lining, which form so many flues, indicated by the dotted lines *x*, in *fig.* 1156 (the dotted circle representing the cylinder). These ribs are perforated with occasional apertures, as shown in *fig.* 1155, for the purpose of connecting the adjoining flues; but the main bearing of the hollow cylinder is given by five piers, *b*, *b*, *c*, formed of bricks projecting over and beyond each other. One of these piers *c*, is placed at the back of the fireplace, and the other four at the sides *b*, *b*. These project nearly into the centre, in order to support and strengthen the bottom; while the flues pass up between them, unite at the top of the cylinder in the dome L, and discharge the smoke by the chimney N.

1155



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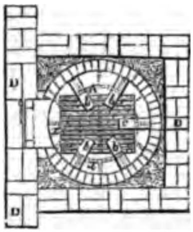

The lining F, E, E, of the chimney is open on one side to form the door, by which the cylinder is charged and discharged. The opening is permanently closed as high as *k*, *fig.* 1155, by an iron plate plastered over with fire clay; above this it is left open, and shut merely with temporary brick-work while the furnace is going. When this is removed, the furnace can be filled or emptied through the opening, the cylindric crucible having a correspondent aperture in its side, which is closed in the following ingenious way, while the furnace is in action. The workman first spreads a layer of clay round the edge of the opening, he then sticks the stems of broken pipes across from one side to the other, and plasters up the interstices with clay, exactly like the lath-and-plaster work of a ceiling. The whole of the cylinder, indeed, is constructed in this manner, the bottom being composed of a great many fragments of pipe stems, radiating to the centre; these are coated at the circumference with a layer of clay. A number of bowls of broken pipes are inserted in the clay; in these other fragments are placed upright, to form the sides of the cylinder. The ribs round the outside, which form the flues, are made in the same way, as well as the dome L; by which means the cylindric case may be made very strong, and yet so thin as to require little clay in the building, a moderate fire to heat it, while it is not apt to split asunder. The pipes are arranged within, as shown in the figure, with their bowls resting against the circumference, and their ends supported on circular pieces of clay *r*, which are set up in the centre for that purpose. Six small ribs are made to project inwards all round the crucible, at the proper heights, to support the different ranges of pipes, without having so many resting on each other as to endanger their being crushed by the weight. By this mode of distribution, the furnace may contain 50 gross, or 7200 pipes, all baked within 8 or 9 hours; the fire being gradually raised, or damped if occasion be, by a plate partially slid over the chimney top.

TODDY, *Sura*, *Mee-ra*, sweet juice.—The proprietors of cocoa-nut plantations in the peninsula of India, and in the Island of Ceylon, instead of collecting a crop of nuts, frequently reap the produce of the trees by extracting sweet juice from the flower-stalk. When the flowering branch is half shot, the toddy-drawers bind the stock round with a young cocoa-nut leaf in several places, and beat the spadix with a short baton of ebony. This beating is repeated daily for ten or twelve days, and about the end of that period a portion of the flower-stalk is cut off. The stump then begins to bleed, and an earthen vessel (chatty) or a calabash is suspended under it, to receive the juice, which is by the Europeans called *toddy*.

A thin slice is taken from the stump daily, and the toddy is removed twice a day. A cocoa-nut frequently pushes out a new *spadix* once a month; and after each spadix begins to bleed, it continues to produce freely for a month, by which time another is ready to supply its place. The old spadix continues to give a little juice for another month, after which it withers; so that there are sometimes two pots attached to a tree at one time, but never more. Each of these spadices, if allowed to grow, would produce a bunch of nuts from two to twenty. Trees in a good soil produce twelve bunches in the year; but when less favorably situated, they often do not give more than six bunches. The quantity of six English pints of toddy is sometimes yielded by a tree daily.

Toddy is much in demand as a beverage in the neighborhood of villages, especially where European troops are stationed. When it is drunk before sunrise, it is a cool, delicious, and particularly wholesome beverage; but by eight or nine o'clock fermentation has made some progress, and it is then highly intoxicating.*

TOLU, is a brownish-red balsam, extracted from the stem of the *Myroxilon toluiferum*, a tree which grows in South America. It is composed of resin, oil, and benzoic acid. Having an agreeable odor, it is sometimes used in perfumery. It has a place in the Materia Medica, but for what good reason I know not.

TOMBAC, is a white alloy of copper.

TONKA BEAN, the fruit of the *Dipterix odorata*, affords a concrete crystalline volatile oil (*stearoptène*), called *coumarine* by the French. It is extracted by digestion with alcohol, which dissolves the stearoptène, and leaves a fat oil. It has an agreeable smell, and a warm taste. It is fusible at 122° Fahrenheit, and volatile at higher heats.

TOPAZ. See Lapidary.

TORTOISE-SHELL, or rather scales, a horny substance, that covers the hard strong covering of a bony contexture, which encloses the *Testudo imbricata*, Linn. The lamellæ or plates of this tortoise are 13 in number, and may be readily separated from the bony part by placing fire beneath the shell, whereby they start asunder. They vary in thickness from one eighth to one quarter of an inch, according to the age and size of the animal, and weigh from 5 to 25 pounds. The larger the animal, the better is the shell. This substance may be softened by the heat of boiling water; and if compressed in this state by screws in iron or brass moulds, it may be bent into any shape. The moulds being then plunged in cold water, the shell becomes fixed in the form imparted by the mould. If the turnings or filings of tortoise-shell be subjected skilfully to gradually increased compression between moulds immersed in boiling water, compact objects of any desired ornamental figure or device may be produced. The soldering of two pieces of scale is easily effected, by placing their edges together, after they are nicely filed to one bevel, and then squeezing them strongly between the long flat jaws of hot iron pincers, made somewhat like a hairdresser's curling-tongs. The pincers should be strong, thick, and just hot enough to brown paper slightly, without burning it. They may be soldered also by the heat of boiling water, applied along with skilful pressure. But in whatever way this process is attempted, the surfaces to be united should be made very smooth, level, and clean; the least foulness, even the touch of the finger, or breathing upon them, would prevent their coalescence. See Horn.

TOUCH-NEEDLES, and TOUCH-STONE, are means of ascertaining the quality of gold trinkets. See Assay.

TOW. See Flax.

TRAGACANTH, GUM. (*Gomme adracante*, Fr.; *Traganth* Germ.) See Gum.

TRAVERTINO. See Tufa.

TREACLE, is the viscid brown uncrystallizable sirup which drains from the sugar-refining moulds. Its specific gravity is generally 1·4, and it contains upon an average 75 per cent. of solid matter, by my experiments.

TRIPOLI (*Terre pourrie*, Fr.; *Tripel*, Germ.), rotten-stone, is a mineral of an earthy fracture, a yellowish-gray or white color, composition impalpably fine, meager to the touch, does not adhere to the tongue, and burns white. Its analogue, the *Polierschiefer*, occurs in thin flat foliated pieces, of the above colors, occasionally striped; soft, absorbent of water; spec. grav. 1·9 to 2·2.

M. Ehrenberg has shown that both of these friable homogeneous rocks, which consist almost entirely of silica, are actually composed of the exuviæ or rather the skeletons of infusoria (*animalcula*) of the family of *Barcillariæ*, and the genera *Cocconema*, *Gonphonema*, &c. They are recognised with such distinctness in the microscope, that their analogies with living species may be readily traced; and in many cases there are no appreciable differences between the living and the petrified. The species are distinguished by the number of partitions or transverse lines upon their bodies. The length is about $\frac{1}{288}$ of a line. M. Ehrenberg made his observations upon the tripolis of Billen in Bohemia, of Santafiora in Tuscany, of the Isle of France, and of Francisbad, near Eger.

The meadow iron ore (*Fer limoneux des marais*) is composed almost wholly of the *Gaellonella ferruginea*. Most of these infusoria are lacustrine; but others are marine, particularly the *tripolis* of the Isle of France.

According to the chemical analysis of Bucholz, tripoli consists of—silica, 81; alumina, 1·5; oxyde of iron, 8; sulphuric acid, 3·45; water, 4·55. This specimen was probably found in a coal-field. The tripoli of Corfu is reckoned the best for scouring or brightening brass and other metals. Mr. Phillips found in the Derbyshire rotten-stone (near

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* Contributions to the History of the Cocoa-nut Tree. By Henry Marshall, Esq., Deputy Inspector of Hospitals.

Bakewell), 86 of alumina, 4 of silica, and 10 of carbon—being a remarkable difference in composition from the Bohemian.

TUFA, or TUF, is a gray deposite of calcareous carbonate, from springs and streams.

TULA METAL, is an alloy of silver, copper, and lead.

TUNGSTEN (Eng. and Fr.; *Wolfram*, Germ.), is a peculiar metal, which occurs in the state of an acid (the *tungstic*), combined with various bases, as with lime, the oxydes of iron, manganese, and lead. The metal is obtained by reduction of the ore, or the deoxydizement of the acid, in the form of a dark steel-gray powder, which assumes under the burnisher a feeble metallic lustre. Its specific gravity is 17·22.

TURBITH MINERAL, is the yellow subsulphate of mercury.

TURF (*Peat*, Scotch; *Tourbe*, Fr.; *Torf*, Germ.), consists of vegetable matter, chiefly of the moss family, in a state of partial decomposition by the action of water. Cut, during summer, into brick-shaped pieces, and dried, it is extensively used as fuel by the peasantry in every region where it abounds. The dense black turf, which forms the lower stratum of a peat-moss, is much contaminated with iron, sulphur, sand, &c., while the lighter turf of the upper strata, though nearly pure vegetable matter, is too bulky for transportation, and too porous for factory fuel. These defects have been happily removed by Mr. Williams, managing director of the Dublin Steam Navigation Company, who has recently obtained a patent for a method of converting the lightest and purest beds of peat-moss, or bog, into the four following products: 1. A brown combustible solid, denser than oak; 2. A charcoal, twice as compact as that of hard wood; 3. A factitious coal; and 4. A factitious coke; each of which possesses very valuable properties.

Mr. D'Ernst, artificer of fire-works to Vauxhall, has proved, by the severe test of colored fires, that the turf charcoal of Mr. Williams is 20 per cent. more combustible than that of oak. Mr. Oldham, engineer of the Bank of England, has applied it in softening his steel plates and dies, with remarkable success. But one of the most important results of Mr. Williams's invention is, that with 10 cwts. of pitcoal, and 2½ cwts. of his factitious coal, the same steam power is now obtained, in navigating the Company's ships, as with 17½ cwts. of pitcoal alone; thereby saving 30 per cent. in the stowage of fuel. What a prospect is thus opened up of turning to admirable account the unprofitable bogs of Ireland; and of producing, from their inexhaustible stores, a superior fuel for every purpose of arts and engineering!

The turf is treated as follows:—Immediately after being dug, it is triturated under revolving edge-wheels, faced with iron plates perforated all over their surface, and is forced by the pressure through these apertures, till it becomes a species of pap, which is freed from the greater part of its moisture by squeezing in a hydraulic press between layers of caya cloth, then dried, and coked in suitable ovens.—(See CHARCOAL, and PIT-COAL, COKING OF.) Mr. Williams makes his factitious coal by incorporating with pitch or rosin, melted in a caldron, as much of the above charcoal, ground to powder, as will form a doughy mass, which is moulded into bricks in its hot and plastic state. From the experiments of M. Le Sage, detailed in the 5th volume of "The Repertory of Arts," charred ordinary turf seems to be capable of producing a far more intense heat than common charcoal. It has been found preferable to all other fuel for case-hardening iron, tempering steel, forging horse-shoes, and welding gun-barrels. Since turf is partially carbonized in its native state, when it is condensed by the hydraulic press, and fully charred, it must evidently afford a charcoal very superior in calorific power to the porous substance generated from wood by fire.

TURKEY RED, is a brilliant dye produced on cotton goods by MADDER.

TURMERIC, *Curcuma*, *Terra merita*, (*Souchet*, or *Safran des Indes*, Fr.; *Gelbwurzel*, Germ.), is the root of the *Curcuma longa* and *rotunda*, a plant which grows in the East Indies, where it is much employed in dyeing yellow, as also as a condiment in curry sauce or powder. The root is knotty, tubercular, oblong, and wrinkled; pale-yellow without, and brown-yellow within; of a peculiar smell, a taste bitterish and somewhat spicy. It contains a peculiar yellow principle, called *curcumine*, a brown coloring-matter, a volatile oil, starch, &c. The yellow tint of turmeric is changed to brown-red by alkalis, alkaline earths, subacetate of lead, and several metallic oxydes; for which reason, paper stained with it is employed as a chemical test.

Turmeric is employed by the wool-dyers for compound colors which require an admixture of yellow, as for cheap browns and olives. As a yellow dye, it is employed only upon silk. It is a very fugitive color. A yellow lake may be made by boiling turmeric powder with a solution of alum, and pouring the filtered decoction upon pounded chalk.

TURNSOLE. See ARCHIL and LITMUS.

TURQUOIS. See LAPIDARY.

TURPENTINE (*Térébinthine*, Fr.; *Terpenthin*, Germ.), is a substance which flows out of incisions made in the stems of several species of pines. It has the consistence and gray-yellow color of honey. It has a smell which is not disagreeable to many persons, a warm, sharp, bitterish taste; dries into a solid in the air, with the evaporation of its volatile oil. It becomes quite fluid at a moderate elevation of temperature, and burns at a higher heat, with a bright but a very fuliginous flame. There are several varieties of turpentine.

1. *Common turpentine*, is extracted from incisions in the *Pinus abies* and *Pinus silvestris*. It has little smell; but a bitter burning taste. It consists of the volatile oil of turpentine to the amount of from 5 to 25 per cent.; and of rosin or colophony.

2. *Venice turpentine*, is extracted from the *Pinus larix* (larch), and the French turpentine from the *Pinus maritima*. The first comes from Styria, Hungary, the Tyrol, and Switzerland, and contains from 18 to 25 per cent. of oil; the second, from the south of France, and contains no more than 12 per cent. of oil. The oil of all the turpentines is extracted by distilling them along with water. They dissolve in all proportions in alcohol, without leaving any residuum. They also combine with alkaline leys, and in general with the salifiable bases. Venice turpentine contains also succinic acid.

3. Turpentine of Strasbourg is extracted from the *Pinus picea* and *Abies excelsa*. It affords 33·5 per cent. of volatile oil, and some volatile or crystallizable resin, with extractive matter and succinic acid.

4. Turpentine of the Carpathian mountains, and of Hungary; the first of which comes from the *Pinus cembra*, and the second from the *Pinus mugos*. They resemble that of Strasbourg.

5. Turpentine of Canada, called Canada balsam, is extracted from the *Pinus canadensis* and *balsamea*. Its smell is much more agreeable than that of the preceding species.

6. Turpentine of Cyprus or Chio, is extracted from the *Pistacea terebinthus*. It has a yellow, greenish, or blue-green color. Its smell is more agreeable, and taste less acrid, than those of the preceding sorts.

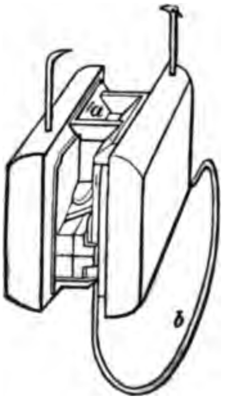
Common turpentine imported into the United Kingdom, in 1836, 370,981 cwts. 1 qr. 26 lbs.; in 1837, 415,023 cwts. 1 qr. 10 lbs. Retained for home consumption, in 1836, 341,693 cwts. 18 lbs.; in 1837, 405,772 cwts. 2 qrs. 14 lbs. Duty received, in 1836, £74,052; in 1837, £87,918.

TURPENTINE, OIL OF, sometimes called essence of turpentine. As found in commerce, it contains more or less rosin, from which it may be freed by re-distillation along with water. It is colorless, limpid, very fluid, and possessed of a very peculiar smell. Its specific gravity, when pure, is 0·870; that of the oil commonly sold in London, is 0·875. It always reddens litmus paper, from containing a little succinic acid. According to Oppermann, the oil which has been repeatedly rectified over chloride of calcium, consists of 84·60 carbon, 11·735 hydrogen, and 3·67 oxygen. When oil of turpentine contains a little alcohol, it burns with a clear flame; but otherwise it affords a very smoky flame. Chlorine inflames this oil; and muriatic acid converts it into a crystalline substance, like camphor. It is employed extensively in varnishes, paints, &c., as also in medicine.

TUTENAG, is an alloy of copper and zinc.

TYPE, (*Caractère*, Fr.; *Druckbuchstabe*, Germ.) The first care of the letter-cutter is to prepare well-tempered steel punches, upon which he draws or marks the exact shape of the letter, with pen and ink if it be large, but with a smooth blunted point of a needle if it be small; and then, with a proper sized and shaped graver and sculptor, he digs or scoops out the metal between the strokes upon the face of the punch, leaving the marks untouched and prominent. He next works the outside with files till it be fit for the matrix. Punches are also made by hammering down the hollows, filing up the edges, and then hardening the soft steel. Before he proceeds to sink and justify the matrix, he provides a mould to justify them by, of which a good figure is shown in plate xv., *Miscellany*, *figs.* 2, 3, of *Rees's Cyclopædia*.

1157



A matrix is a piece of brass or copper, about an inch and a half long, and thick in proportion to the size of the letter which it is to contain. In this metal the face of the letter intended to be cast is sunk, by striking it with the punch to a depth of about one eighth of an inch. The mould, *fig.* 1157, in which the types are cast, is composed of two parts. The outer part is made of wood, the inner of steel. At the top it has a hopper-mouth *a*, into which the fused type-metal is poured. The interior cavity is as uniform as if it had been hollowed out of a single piece of steel; because each half, which forms two of the four sides of the letter, is exactly fitted to the other. The matrix is placed at the bottom of the mould, directly under the centre of the orifice, and is held in its position by a spring *b*. Every letter that is cast can be loosened from the matrix only by removing the pressure on the spring.

A good type-foundry is always provided with several furnaces, each surmounted with an iron pot containing the melted alloy, of 3 parts of lead and 1 of antimony. Into this pot the founder dips the very small iron ladle, to lift merely as much metal as will cast a single letter at a time. Having poured in the metal with his right hand, and returned the ladle to the melting-pot, the founder throws up his left hand, which holds the mould, above his head, with a sudden jerk, supporting it with his right hand. It is this movement which forces the metal into all the interstices of the matrix; for without it, the metal, especially in the smaller moulds, would not be able to expel the air and reach the bottom. The pouring in the metal, the throwing up the mould, the unclosing it, removing the pressure of the spring, picking out the cast letter, closing the mould again, and re-applying the spring to be ready for a new operation, are all performed with such astonishing rapidity and precision, that a skilful workman will turn out five hundred good letters in an hour, being at the rate of one every eighth part of a minute. A considerable piece of metal remains attached to the end of the type as it quits the mould. There are nicks upon the lower edge of the types, to enable the compositor to place them upright, without looking at them.

From the table of the *caster*, the heap of types turned out of his mould, is transferred from time to time to another table, by a boy, whose business it is to break off the superfluous metal, and that he does so rapidly as to clear from 2000 to 5000 types in an hour; a very remarkable despatch, since he must seize them by their edges, and not by their feeble flat sides. From the breaking-off boy, the types are taken to the *rubber*, a man who sits in the centre of the workshop with a grit-stone slab on a table before him, and having on the fore and middle finger of his right hand a piece of tarred leather, passes each broad side of the type smartly over the stone, turning it in the movement, and that so dexterously, as to be able to rub 2000 types in an hour.

From the rubber, the types are conveyed to a boy, who, with equal rapidity, sets them up in lines, in a long shallow frame, with their faces uppermost and nicks outwards. This frame, containing a full line, is put into the dresser's hands, who polishes them on each side, and turning them with their faces downwards, cuts a groove or channel in their bottom, to make them stand steadily on end. It is essential that each letter be perfectly symmetrical and square; the least inequality of their length would prevent them from making a fair impression; and were there the least obliquity in their sides, it would be quite impossible, when 200,000 single letters are combined, as in one side of the *Times* newspaper, that they could hold together as they require to do, when wedged up in the chases, as securely as if that side of type formed a solid plate of metal. Each letter is finally tied up in lines of convenient length, the proportionate numbers of each variety, small letters, points, large capitals, small capitals, and figures, being selected, when the fount of type is ready for delivery to the printer.

The sizes of types cast in this country vary from the smallest, called diamond, of which 205 lines are contained in a foot length, to those letters employed in placards, of which a single letter may be three or four inches high. The names of the different letters and their dimensions, or the number of lines which each occupies in a foot, are stated in the following table:—

Double Pica, - -	41½	Small Pica, - -	83	Nonpareil, - -	143
Paragon, - -	44½	Long Primer, -	89	Agate, - -	166
Great Primer, - -	51¼	Bourgeois, - -	102¼	Pearl, - - -	178
English, - -	64	Brevier, - -	112½	Diamond, - -	205
Pica, - - -	71½	Minion, - -	128		

T. Aspinwall, Esq., the American Consul, obtained, in May, 1828, a patent for an improved method of casting printing types by means of a mechanical process, being a communication from a foreigner residing abroad. The machine is described, with six explanatory figures, in the second series of Newton's Journal, vol. v. page 212. The patentee does not claim, as his invention, any of the parts separately, but the general process and arrangement of machinery; more particularly the manner of suspending a swing table (upon which the working parts are mounted) out of the horizontal and perpendicular position; the mode of moving the table with the parts of the mould towards the melting pot; the manner of bringing the parts of the mould together, and keeping them closed during the operation of casting the types. Several other mechanical schemes have been proposed for founding types, but I have been informed by very competent judges, Messrs. Clowes, that none of them can compete in practical utility with that dexterity and precision of handiwork, which I have often seen practised in their great printing establishment in Stamford street.

U.

ULTRAMARINE (*Outremer*, Fr.; *Ultramarin*, Germ.), is a beautiful blue pigment obtained from the variegated blue mineral, called lazulite (*lapis lazuli*), by the following process:—Grind the stone to fragments, rejecting all the colorless bits, calcine at a red heat, quench in water, and then grind to an impalpable powder along with water, in a paint-mill (see PAINTS, GRINDING OF), or with a porphyry slab and muller. The paste, being dried, is to be rubbed to powder, and passed through a silk sieve. 100 parts of it are to be mixed with 40 of rosin, 20 of white wax, 25 of linseed oil, and 15 of Burgundy pitch, previously melted together. This resinous compound is to be poured hot into cold water; kneaded well first with two spatulas, then with the hands, and then formed into one or more small rolls. Some persons prescribe leaving these pieces in the water during fifteen days, and then kneading them in it, whereby they give out the blue pigment, apparently because the ultramarine matter adheres less strongly than the *gangue*, or merely silicious matter of the mineral, to the resinous paste. MM. Clement and Desormes, who were the first to divine the true nature of this pigment, think that the soda contained in the lazulite, uniting with the oil and the rosin, forms a species of soap, which serves to wash out the coloring-matter. If it should not separate readily, water heated to about 150° F. should be had recourse to. When the water is sufficiently charged with blue color, it is poured off and replaced by fresh water; and the kneading and change of water are repeated till the whole of the color is extracted. Others knead the mixed resinous mass under a slender stream of water, which runs off with the color into a large earthen pan. The first waters afford, by rest, a deposite of the finest ultramarine; the second, a somewhat inferior article, and so on. Each must be washed afterwards with several more waters, before they acquire the highest quality of tone; then dried separately, and freed from any adhering particles of the pitchy compound by digestion in alcohol. The remainder of the mass being melted with oil, and kneaded in water containing a little soda or potash, yields an inferior pigment, called *ultramarine ashes*. The best *ultramarine* is a splendid blue pigment, which works well with oil, and is not liable to change by time. Its price in Italy was five guineas the ounce, a few years ago, but it is now greatly reduced.

The blue color of *lazulite* had been always ascribed to iron, till MM. Clement and Desormes, by a most careful analysis, showed it to consist of—silica, 34; alumina, 33; sulphur, 3; soda, 22; and that the iron, carbonate of lime, &c., were accidental ingredients, essential neither to the mineral, nor to the pigment made from it. By another analyst, the constituents are said to be—silica, 44; alumina, 35; and soda, 21; and by a third, potassa was found instead of soda, showing shades of difference in the composition of the stone.

Till a few years ago, every attempt failed to make ultramarine artificially. At length, in 1828, M. Guimet resolved the problem, guided by the analysis of MM. Clement and Desormes, and by an observation of M. Tassaert, that a blue substance like ultramarine was occasionally produced on the sandstone hearths of his reverberatory soda furnaces. Of M. Guimet's finest pigment I received a bottle several years ago, from my friend M. Merimée, Secretary of the *Ecole de Beaux Arts*, which has been found by artists little, if any, inferior to the lazulite ultramarine. M. Guimet sells it at sixty francs per pound French,—which is little more than two guineas the English pound. He has kept his process secret. But M. Gmelin, of Tübingen, has published a prescription for making it; which consists in enclosing carefully in a Hessian crucible a mixture of two parts of sulphur, and one of dry carbonate of soda, heating them gradually to redness till the mass fuses, and then sprinkling into it by degrees another mixture, of silicate of soda, and aluminate of soda; the first containing seventy-two parts of silica, and the second seventy parts of alumina. The crucible must be exposed after this for an hour to the fire. The ultramarine will be formed by this time; only it contains a little sulphur, which can be separated by means of water. M. Persoz, professor of chemistry at Strasbourg, has likewise succeeded in making an ultramarine, of perhaps still better quality than that of M. Guimet. Lastly, M. Robiquet has announced, that it is easy to form ultramarine, by heating to redness a proper mixture of kaolin (China clay), sulphur, and carbonate of soda. It would therefore appear, from the preceding details, that ultramarine may be regarded as a compound of silicate of alumina, silicate of soda, with sulphuret of sodium; and that to the reaction of the last constituent upon the former two, it owes its color.

UMBER, is a massive mineral; fracture large and flat; conchoidal in the great, very fine earthy in the small; dull; color, liver, chestnut,—dark yellowish brown; opaque; does not soil, but writes; adheres strongly to the tongue, feels a little rough and meager, and is very soft; specific gravity 2·2. It occurs in beds with brown jasper in the Island of Cyprus, and is used by painters as a brown color, and to make varnish dry quickly

URANIUM, is a rare metal, first discovered by Klaproth, in the black mineral called *pechblende*, found in a mine near Johann-Georgen-Stadt, in Saxony, and which is a sulphuret of uranium. A double phosphate of uranium and copper, called *green uranite*, and *uran mica*, occurs in Cornwall. It has been reduced to the metallic state by various devices, but it has hardly the appearance of metal to the naked eye, and from the rarity of its ores is not likely to be of any importance in the arts.

URAO, is the native name of a sesquicarbonate of soda found at the bottom of certain lakes in Mexico, especially to the north of Zacatecas, and in several other provinces; also in South America at Columbia, 48 English miles from Merida.

V.

VALONIA, is a kind of acorn, imported from the Levant and the Morea for the use of tanners, as the husk or cup contains abundance of tannin. The quantity imported for home consumption in 1836, was 80,511 cwts.; of which Turkey furnished 58,724, Italy and the Italian islands, 7209.

VANADIUM, is a metal discovered by Sefström, in 1830, in a Swedish iron, remarkable for its ductility, extracted from the iron mine of Jaberg, not far from Jönköping. Its name is derived from Vanadis, a Scandinavian idol. This metal has been found in the state of vanadic acid, in a lead ore from Zimapan, in Mexico. The finery cinders of the Jaberg iron contain more vanadium than the metal itself. It exists in it as vanadic acid. For the reduction of this acid to vanadium, see Berzelius's *Traité de Chimie*, vol. iv. p. 644. Vanadium is white, and when its surface is polished, it resembles silver or molybdenum more than any other metal. It combines with oxygen into two oxydes and an acid.

The vanadate of ammonia, mixed with infusion of nutgalls, forms a black liquid, which is the best writing-ink hitherto known. The quantity of the salt requisite is so small as to be of no importance when the vanadium comes to be more extensively extracted. The writing is perfectly black. The acids color it blue, but do not remove it, as they do tannate of iron: the alkalis, diluted so far as not to injure the paper, do not dissolve it; and chlorine, which destroys the black color, does not, however, make the traces illegible, even when they are subsequently washed with a stream of water. It is perfectly fluent, and, being a chemical solution, stands in want of no viscid gum to suspend the color, like common ink. The influence of time upon it remains to be tried.

VANILLA, is the oblong narrow pod of the *Epidendron vanilla*, Linn., of the natural family *Orchideæ*, which grows in Mexico, Colombia, Peru, and on the banks of the Oronoco.

The best comes from the forests round the village of Zentila, in the intendancy of Oaxaca.

The vanilla plant is cultivated in Brazil, in the West Indies, and some other tropical countries, but does not produce fruit of such a delicious aroma as in Mexico. It clings like a parasite to the trunks of old trees, and sucks the moisture which their bark derives from the lichens, and other cryptogamia, but without drawing nourishment from the tree itself, like the ivy and mistletoe. The fruit is subcylindric, about 8 inches long, one-celled, siliquose, and pulpy within. It should be gathered before it is fully ripe.

When about 12000 of these pods are collected, they are strung like a garland by their lower end, as near as possible to the foot-stalk; the whole are plunged for an instant in boiling water to blanch them; they are then hung up in the open air, and exposed to the sun for a few hours. Next day they are lightly smeared with oil, by means of a feather, or the fingers; and are surrounded with oiled cotton, to prevent the valves from opening. As they become dry, on inverting their upper end, they discharge a viscid liquid from it, and they are pressed at several times with oiled fingers to promote its flow. The dried pods lose their appearance, grow brown, wrinkled, soft, and shrink into one fourth of their original size. In this state they are touched a second time with oil, but very sparingly; because, with too much oil, they would lose much of their delicious perfume. They are then packed for the market, in small bundles of 50 or 100 in each, enclosed in lead foil, or tight metallic cases. As it comes to us, vanilla is a capsular fruit, of the thickness of a swan's quill, straight, cylindrical, but somewhat flattened, truncated at the top, thinned off at the ends, glistening, wrinkled, furrowed lengthwise, flexible, from 5 to 10 inches long, and of a reddish-brown color. It contains a pulpy parenchyma, soft, unctuous, very brown, in which are imbedded black, brilliant, very small seeds. Its smell is ambrosiacal and aromatic; its taste hot, and rather sweetish. These properties seem to depend upon an essential oil, and also upon benzoic acid, which forms efflorescences upon the surface of the fruit. The pulpy part possesses alone the aromatic quality; the pericarpium has hardly any smell.

The kind most esteemed in France, is called *leq* vanilla; it is about 6 inches long, from ¼ to ⅓ of an inch broad, narrowed at the two ends, and curved at the base; somewhat soft and viscid, of a dark-reddish color, and of a most delicious flavor, like that of Balsam of Peru. It is called vanilla *givrées*, when it is covered with efflorescences of benzoic acid, after having been kept in a dry place, and in vessels not hermetically closed.

The second sort, called *vanilla simarona*, or bastard, is a little smaller than the preceding, of a less deep brown hue, drier, less aromatic, destitute of efflorescence. It is said to be the produce of the wild plant, and is brought from St. Domingo.

A third sort, which comes from Brazil, is the *vanillon*, or large vanilla of the French market; the *vanilla pamprona* or *bova* of the Spaniards. Its length is from 5 to 6 inches; its breadth from one half to three quarters of an inch. It is brown, soft, viscid, almost always open, of a strong smell, but less agreeable than the *leq*. It is sometimes a little spoiled by an incipient fermentation. It is cured with sugar, and enclosed in tin-plate boxes, which contain from 20 to 60 pods.

Vanilla, as an aromatic, is much sought after by makers of chocolate, ices, and creams; by confectioners, perfumers, and liquorists, or distillers. It is difficultly reduced to fine particles; but it may be sufficiently attenuated by cutting it into small bits, and grinding these along with sugar. The odorous principle can, for some purposes, be extracted by alcohol. Their analysis by Bucholz is unsatisfactory, and refers obviously to the coarsest sort. Berzelius says that the efflorescences are not acid.

VAPOR (*Vapeur*, Fr.; *Dampf*, Germ.), is the state of elastic or aëriform fluidity into which any substance, naturally solid or liquid at ordinary temperatures, may be converted by the agency of heat. See EVAPORATION.

VARNISH (*Vernis*, Fr.; *Firniss*, Germ.), is a solution of resinous matter, which is spread over the surface of any body, in order to give it a shining, transparent, and hard coat, capable of resisting, in a greater or less degree, the influences of air and moisture. Such a coat consists of the resinous parts of the solution, which remain in a thin layer upon the surface, after the liquid solvent has either evaporated away, or has dried up. When large quantities of spirit varnish are to be made, a common still, mounted with its capital and worm, is the vessel employed for containing the materials, and it is placed in a steam or water bath. The capital should be provided with a stuffing-box, through which a stirring-rod may pass down to the bottom of the still, with a cross-piece at its lower end, and a handle or winch at its top. After heating the bath till the alcohol boils and begins to distil, the heat ought to be lowered, that the solution may continue to proceed in an equable manner, with as little evaporation of spirit as possible. The operation may be supposed to be complete when the rod can be easily turned round. The varnish must be passed through a silk sieve of proper fineness; then filtered through porous paper, or allowed to clear leisurely in stone jars. The alcohol which has come over should be added to the varnish, if the just proportions of the resins have been introduced at first. The following are reckoned good French recipes for varnishes:—

White spirit varnish.—Sandarach, 250 parts; mastic in tears, 64; elemi resin, 32; turpentine (Venice), 64; alcohol, of 85 per cent., 1000 parts by measure.

The turpentine is to be added after the resins are dissolved. This is a brilliant varnish, but not so hard as to bear polishing.

Varnish for the wood toys of Spa. Tender copal, 75 parts; mastic, 12·5; Venice turpentine, 6·5; alcohol, of 95 per cent., 100 parts by measure; water ounces, for example, if the other parts be taken in ounces.

The alcohol must be first made to act upon the copal, with the aid of a little oil of lavender or camphor, if thought fit; and the solution being passed through a linen cloth, the mastic must be introduced. After it is dissolved, the Venice turpentine, previously melted in a water-bath, should be added; the lower the temperature at which these operations are carried on, the more beautiful will the varnish be. This varnish ought to be very white, very drying, and capable of being smoothed with pumice-stone and polished.

Varnish for certain parts of carriages.—Sandarach, 190 parts; pale shellac, 95; resin, 125; turpentine, 190; alcohol, at 85 per cent., 1000 parts by measure.

Varnish for cabinet-makers.—Pale shellac, 750 parts; mastic, 64; alcohol, of 90 per cent., 1000 parts by measure. The solution is made in the cold, with the aid of frequent stirring. It is always muddy, and is employed without being filtered.

With the same resins and proof spirit a varnish is made for the bookbinders to do over their morocco leather.

The varnish of Watin, for gilded articles.—Gum lac, in grain, 125 parts; gambege, 125; dragon's blood, 125; annotto, 125; saffron, 32. Each resin must be dissolved in

1000 parts by measure, of alcohol of 90 per cent.; two separate tinctures must be made with the dragon's blood and annotto, in 1000 parts of such alcohol; and a proper proportion of each should be added to the varnish, according to the shade of golden color wanted.

For fixing engravings or lithographs upon wood, a varnish called *mordant* is used in France, which differs from others chiefly in containing more Venice turpentine, to make it sticky; it consists of—sandarach, 250 parts; mastic in tears, 64; rosin, 125; Venice turpentine, 250; alcohol, 1000 parts by measure.

Copal varnish.—Hard copal, 300 parts; drying linseed or nut oil, from 125 to 250 parts; oil of turpentine, 500; these three substances are to be put into three separate vessels; the copal is to be fused by a somewhat sudden application of heat; the drying oil is to be heated to a temperature a little under ebullition, and is to be added by small portions at a time to the melted copal. When this combination is made, and the heat a little abated, the essence of turpentine, likewise previously heated, is to be introduced by degrees; some of the volatile oil will be dissipated at first; but more being added, the union will take place. Great care must be taken to prevent the turpentine vapor from catching fire, which might occasion serious accidents to the operator. When the varnish is made, and has cooled down to about the 130th degree of Fahr., it may be strained through a filter, to separate the impurities and undissolved copal.

Almost all varnish-makers think it indispensable to combine the drying oil with the copal, before adding the oil of turpentine; but in this they are mistaken. Boiling oil of turpentine combines very readily with fused copal; and, in some cases, it would probably be preferable to commence the operation with it, adding it in successive small quantities. Indeed, the whitest copal varnish can be made only in this way; for if the drying oil have been heated to nearly its boiling point, it becomes colored, and darkens the varnish.

This varnish improves in clearness by keeping. Its consistence may be varied by varying the proportions of the ingredients, within moderate limits. Good varnish, applied in summer, should become so dry in 24 hours that the dust will not stick to it, nor receive an impression from the fingers. To render it sufficiently dry and hard for polishing, it must be subjected for several days to the heat of a stove.

Milk of wax is a valuable varnish, which may be prepared as follows:—Melt in a porcelain capsule a certain quantity of white wax, and add to it, while in fusion, an equal quantity of spirit of wine, of sp. grav. 0·830; stir the mixture, and pour it upon a large porphyry slab. The granular mass is to be converted into a paste by the muller, with the addition, from time to time, of a little alcohol; and as soon as it appears to be smooth and homogeneous, water is to be introduced in small quantities successively, to the amount of four times the weight of the wax. This emulsion is to be then passed through canvass, in order to separate such particles as may be imperfectly incorporated.

The *milk of wax*, thus prepared, may be spread with a smooth brush upon the surface of a painting, allowed to dry, and then fused by passing a hot iron (salamander) over its surface. When cold, it is to be rubbed with a linen cloth to bring out the lustre. It is to the unchangeable quality of an encaustic of this nature, that the ancient paintings upon the walls of Herculaneum and Pompeii owe their freshness at the present day.

The most recent practical account of the manufacture of varnishes, is that communicated by Mr. J. Wilson Neil to the Society of Arts, and published in the 49th volume of their "Transactions."

The building or shed wherein varnish is made, ought to be quite detached from any buildings whatever, to avoid accidents by fire. For general purposes, a building about 18 feet by 16 is sufficiently large for manufacturing 4000 gallons and upwards annually, provided there are other convenient buildings for the purpose of holding the utensils, and warehousing the necessary stock.

Procure a copper pan, made like a common washing-copper, which will contain from fifty to eighty gallons, as occasion may require; when wanted, set it upon the boiling furnace, and fill it up with linseed oil within five inches of the brim. Kindle a fire in the furnace underneath, and manage the fire so that the oil shall gradually, but slowly, increase in heat for the first two hours; then increase the heat to a gentle simmer; and if there is any scum on the surface, skim it off with a copper ladle, and put the skimming away. Let the oil boil gently for three hours longer; then introduce, by a little at a time, one quarter of an ounce of the best calcined magnesia for every gallon of oil, occasionally stirring the oil from the bottom. When the magnesia is all in, let the oil boil rather smartly for one hour; it will then be sufficient. Lay a cover over the oil, to keep out the dust while the fire is withdrawn and extinguished by water; next uncover the oil, and leave it till next morning; and then, while it is yet hot, ladle it into the carrying-jack, or let it out through the pipe and cock; carry it away, and deposite it in either a tin or leaden cistern, for wooden vessels will not hold it; let it remain to settle for at least three months. The magnesia will absorb all the acid and mucilage from the oil, and fall to the bottom of the cistern, leaving the oil clear and transparent, and fit for use. Recollect, when the oil is taken out, not to disturb the bottoms, which are only fit for black paint.

GENERAL OBSERVATIONS AND PRECAUTIONS TO BE OBSERVED IN MAKING VARNISHES.

Set on the boiling-pot with 8 gallons of oil; kindle the fire; then lay the fire in the gum-furnace; have as many 8lb. bags of gum-copal all ready weighed up, as will be wanted; put one 8lb. into the pot, put fire to the furnace, set on the gum-pot; in three minutes (if the fire is brisk) the gum will begin to fuse and give out its gas, steam, and acid; stir and divide the gum, and attend to the rising of it, as before directed. Eight pounds of copal take in general from sixteen to twenty minutes in fusing, from the beginning till it gets clear like oil, but the time depends very much on the heat of the fire, and the attention of the operator. During the first twelve minutes, while the gum is fusing, the assistant must look to the oil, and bring it to a smart simmer; for it ought to be neither too hot, nor yet too cold, but in appearance beginning to boil, which he is strictly to observe, and, when ready, to call out, "Bear a hand!" Then immediately both lay hold of a handle of the boiling-pot, lift it right up, so as to clear the plate, carry it out and place it on the ash-bed, the maker instantly returning to the gum-pot, while the assistant puts three copper ladlefuls of oil into the copper pouring-jack, bringing it in and placing it on the iron plate at the back of the gum-pot to keep hot until wanted. When the maker finds the gum is nearly all completely fused, and that it will in a few minutes be ready for the oil, let him call out, "Ready oil!" The assistant is then to lift up the oil-jack with both hands; one under the bottom and the other on the handle, laying the spout over the edge of the pot, and wait until the maker calls out, "Oil!" The assistant is then to pour in the oil as before directed, and the boiling to be continued until the oil and gum become concentrated, and the mixture looks clear on the glass; the gum pot is now to be set upon the brick-stand until the assistant puts three more ladlefuls of hot oil into the pouring-jack, and three more into a spare tin for the third run of gum. There will remain in the boiling-pot still 3½ gallons of oil. Let the maker put his right hand down the handle of the gum-pot near to the side, with his left hand near the end of the handle, and with a firm grip lift the gum-pot, and deliberately lay the edge of the gum-pot over the edge of the boiling-pot until all its contents run into the boiling-pot. Let the gum-pot be held, with its bottom turned upwards, for a minute right over the boiling-pot. Observe, that whenever the maker is beginning to pour, the assistant stands ready with a thick piece of old carpet, without holes, and sufficiently large to cover the mouth of the boiling-pot should it catch fire during the pouring, which will sometimes happen if the gum-pot is very hot; should the gum-pot fire, it has only to be kept bottom upwards, and it will go out of itself; but if the boiling-pot should catch fire, during the pouring, let the assistant throw the piece of carpet quickly over the blazing pot, holding it down all round the edges; in a few minutes it will be smothered. The moment the maker has emptied the gum-pot, he throws into it half a gallon of turpentine, and with the *swish* immediately washes it from top to bottom, and instantly empties it into the flat tin jack: he wipes the pot dry, and puts in 8 pounds more gum, and sets it upon the furnace; proceeding with this run exactly as with the last, and afterwards with the third run. There will then be 8 gallons of oil and 24 pounds of gum in the boiling-pot, under which keep up a brisk strong fire until a scum or froth rises and covers all the surface of the contents, when it will begin to rise rapidly. Observe, when it rises near the rivets of the handles, carry it from the fire, and set it on the ash-bed, stir it down again, and scatter in the driers by a little at a time; keep stirring, and if the frothy head goes down, put it upon the furnace, and introduce *gradually* the remainder of the driers, always carrying out the pot when the froth rises near the rivets. In general, if the fire be good, all the time a pot requires to boil, from the time of the last gum being poured in, is about three and a half or four hours; but *time* is no criterion for a beginner to judge by, as it may vary according to the weather, the quality of the oil, the quality of the gum, the driers, or the heat of the fire, &c.; therefore, about the third hour of boiling, try it on a bit of glass, and keep it boiling until it feels strong and stringy between the fingers; it is then boiled sufficiently to carry it on the ash-bed, and to be stirred down until it is cold enough to mix, which will depend much on the weather, varying from half an hour, in dry frosty weather, to one hour in warm summer weather. Previous to beginning to mix, have a sufficient quantity of turpentine ready, fill the pot, and pour in, stirring all the time at the top or surface, as before directed, until there are fifteen gallons, or five tins of oil of turpentine introduced, which will leave it quite thick enough if the gum is good, and has been well run; but if the gum was of a weak quality, and has not been well fused, there ought to be no more than twelve gallons of turpentine mixed, and even that may be too much. Therefore, when twelve gallons of turpentine have been introduced, have a flat saucer at hand, and pour into it a portion of the varnish, and in two or three minutes it will show whether it is too thick; if not sufficiently thin, add a little more turpentine, and strain it off quickly. As soon as the whole is stored away, pour in the turpentine washings, with which the gum-pots have been washed, into the boiling-pot, and with the swish quickly wash down all the varnish from the pot sides; afterwards, with a large piece of woollen rag dipped in pumice-powder, wash and polish every part of the inside of the boiling-pot, performing the same operation on the ladle and stirrers; rinse them with the turpentine washings, and at last rinse them altogether in clean turpentine, which also put to the washings; wipe dry with a clean soft rag the pot, ladle, stirrer, and funnels, and lay the sieve so as to be completely covered with turpentine, which will always keep it from gumming up. The foregoing directions concerning running the gum, and pouring in the oil, and also boiling off and mixing, are, with very little difference, to be observed in the making of all sorts of copal varnishes, except the differences of the quantities of oil, gum, &c., which will be found under the various descriptions by name, which will be hereafter described.

The choice of linseed oil is of peculiar consequence to the varnish-maker. Oil from fine full-grown ripe seed, when viewed in a vial, will appear limpid, pale, and brilliant; it is mellow and sweet to the taste, has very little smell, is specifically lighter than impure oil, and, when clarified, dries quickly and firmly, and does not materially change the color of the varnish when made, but appears limpid and brilliant.

Copal varnishes for fine paintings, &c.—Fuse 8 pounds of the very cleanest pale African gum copal, and, when completely run fluid, pour in two gallons of hot oil, old measure; let it boil until it will string very strong; and in about fifteen minutes, or while it is yet very hot, pour in three gallons of turpentine, old measure, and got from the top of a cistern. Perhaps, during the mixing, a considerable quantity of the turpentine will escape; but the varnish will be so much the brighter, transparent, and fluid; and will work freer, dry more quickly, and be very solid and durable when dry. After the varnish has been strained, if it is found too thick, before it is quite cold, heat as much turpentine, and mix with it, as will bring it to a proper consistence.

Cabinet varnish.—Fuse 7 pounds of very fine African gum copal, and pour in half a gallon of pale clarified oil; in three or four minutes after, if it feel stringy, take it out of doors, or into another building where there is no fire, and mix with it three gallons of turpentine; afterwards strain it, and put it aside for use. This, if properly boiled, will dry in ten minutes; but if too strongly boiled, will not mix at all with the turpentine; and *sometimes*, when boiled with the turpentine, will mix, and yet refuse to incorporate with any other varnish less boiled than itself: therefore it requires a nicety which is only to be learned from practice. This varnish is chiefly intended for the use of japanners, cabinet-painters, coach-painters, &c.

Best body copal varnish for coach-makers, &c.—This is intended for the body parts of coaches and other similar vehicles, intended for polishing.

Fuse 8 lbs. of fine African gum copal; add two gallons of clarified oil (old measure); boil it very slowly for four or five hours, until quite stringy; mix with three gallons and a half of turpentine; strain off, and pour it into a cistern. As they are too slow in drying, coach-makers, painters, and varnish-makers, have introduced to two pots of the preceding varnish, one made as follows:—

8 lbs. of fine pale gum animé;
2 gallons of clarified oil;
3½ gallons of turpentine.
To be boiled four hours.

Quick drying body copal varnish, for coaches, &c.

(1.) 8 lbs. of the best African copal;
2 gallons of clarified oil;
¼ lb. of dried sugar of lead;
3½ gallons of turpentine.
Boiled till stringy, and mixed and strained.

(2.) 8 lbs. of fine gum animé;
2 gallons of clarified oil;
¼ lb. of white copperas;
3½ gallons of turpentine.
Boiled as before.

To be mixed and strained while hot into the other pot. These two pots mixed together will dry in six hours in winter, and in four in summer; it is very useful for varnishing old work on dark colors, &c.

Best pale carriage varnish.

(1.) 8 lbs. 2d sorted African copal;
2½ gallons of clarified oil.
Boiled till very stringy.
¼ lb. of dried copperas;
¼ lb. of litharge;
5½ gallons of turpentine.
Strained, &c.

(2.) 8 lbs. of 2d sorted gum animé;
2½ gallons of clarified oil;
¼ lb. of dried sugar of lead;
¼ lb. of litharge;
5½ gallons of turpentine.
Mix this to the first while hot.

This varnish will dry hard, if well boiled, in four hours in summer, and in six in winter. As the name denotes, it is intended for the varnishing of the wheels, springs, and carriage parts of coaches, chaises, &c.; also, it is that description of varnish which is generally sold to and used by house-painters, decorators, &c.; as from its drying quality and strong gloss, it suits their general purposes well.

Second carriage varnish.

8 lbs. of 2d sorted gum animé;
2¾ gallons of fine clarified oil;
5¼ gallons of turpentine;
¼ lb. of litharge;
¼ lb. of dried sugar of lead;
¼ lb. of dried copperas.
Boiled and mixed as before.

Wainscot varnish.

8 lbs. of 2d sorted gum animé;
3 gallons of clarified oil;
¼ lb. of litharge;
¼ lb. of dried sugar of lead;
5½ gallons of turpentine.
To be well boiled until it strings very strong, and then mixed and strained.

Mahogany varnish is made either with the same proportions, with a little darker gum; otherwise it is wainscot varnish, with a small portion of gold size.

Black japan is made by putting into the set-pot 48 pounds of Naples, or any other of the foreign asphaltums, (except the Egyptian.) As soon as it is melted, pour in 10 gallons of raw linseed oil; keep a moderate fire, and fuse 8 pounds of dark gum animé in the gum-pot; mix it with 2 gallons of hot oil, and pour it into the set-pot. Afterwards fuse 10 pounds of dark or sea amber in the 10 gallon iron pot; keep stirring it while fusing; and whenever it appears to be overheated, and rising too high in the pot, lift it from the fire for a few minutes. When it appears completely fused, mix in 2 gallons of hot oil, and pour the mixture into the set-pot; continue the boiling for 3 hours longer, and during that time introduce the same quantity of driers as before directed; draw out the fire, and let it remain until morning; then boil it until it rolls hard, as before directed; leave it to cool, and afterwards mix with turpentine.

Pale amber varnish.—Fuse 6 pounds of fine picked very pale transparent amber in the gum-pot, and pour in 2 gallons of hot clarified oil. Boil it until it strings very strong. Mix with 4 gallons of turpentine. This will be as fine as body copal, will work very free, and flow well upon any work it is applied to; it becomes very hard, and is the most durable of all varnishes; it is very excellent to mix in copal varnishes, to give them a hard and durable quality. Observe; amber varnish will always require a long time before it is ready for polishing.

Best Brunswick black.—In an iron pot, over a slow fire, boil 45 pounds of foreign asphaltum for at least 6 hours; and during the same time boil in another iron pot 6 gallons of oil which has been previously boiled. During the boiling of the 6 gallons, introduce 6 pounds of litharge gradually, and boil until it feels stringy between the fingers; then ladle or pour it into the pot containing the boiling asphaltum. Let the mixture boil until, upon trial, it will roll into hard pills; then let it cool, and mix it with 25 gallons of turpentine, or until it is of a proper consistence.

Iron-work black.—Put 48 pounds of foreign asphaltum into an iron pot, and boil for 4 hours. During the first 2 hours, introduce 7 pounds of red lead, 7 pounds of litharge, 3 pounds of dried copperas, and 10 gallons of boiled oil; add 1 eight-pound run of dark gum, with 2 gallons of hot oil. After pouring the oil and gum, continue the boiling two hours, or until it will roll into hard pills like japan. When cool, thin it off with thirty gallons of turpentine, or until it is of a proper consistence. This varnish is intended for blacking the iron-work of coaches and other carriages, &c.

A cheap Brunswick black.—Put 28 pounds of common black pitch, and 28 pounds of common asphaltum made from gas tar, into an iron pot; boil both for 8 or 10 hours, which will evaporate the gas and moisture; let it stand all night, and early next morning, as soon as it boils, put in 8 gallons of boiled oil; then introduce, gradually, 10 pounds of red lead, and 10 pounds of litharge, and boil for 3 hours, or until it will roll very hard. When ready for mixing, introduce 20 gallons of turpentine, or more, until of a proper consistence. This is intended for engineers, founders, ironmongers, &c.; it will dry in half an hour, or less, if properly boiled.

Axioms observed in the making of copal varnishes.—The more minutely the gum is run, or fused, the greater the quantity, and the stronger the produce. The more regular and longer the boiling of the oil and gum together is continued, the more fluid or free the varnish will extend on whatever it is applied to. When the mixture of oil and gum is too suddenly brought to string by too strong a heat, the varnish requires more than its just proportion of turpentine to thin it, whereby its oily and gummy quality is reduced, which renders it less durable; neither will it flow so well in laying on. The greater proportion of oil there is used in varnishes, the less they are liable to crack, because the tougher and softer they are. By increasing the proportion of gum in varnishes, the thicker will be the stratum, the firmer they will set solid, and the quicker they will dry. When varnishes are quite new made, and must be sent out for use before they are of sufficient age, they must always be left thicker than if they were to be kept the proper time. Varnish made from African copal alone possesses the most elasticity and transparency. Too much driers in varnish render it opaque and unfit for delicate colors. Copperas does not combine with varnish, but only hardens it. Sugar of lead does combine with varnish. Turpentine improves by age; and varnish by being kept in a warm place. All copal or oil varnishes require age before they are used.

Concluding observations.—All body varnishes are intended and ought to have 1½ lbs. of gum to each gallon of varnish, when the varnish is strained off, and cold; but as the *thinning up*, or quantity of turpentine required to bring it to its proper consistence, depends very much upon the degree of boiling the varnish has undergone, therefore, when the gum and oil have not been strongly boiled, it requires less turpentine for that purpose; whereas, when the gum and oil are very strongly boiled together, a pot of 20 gallons will require perhaps 3 gallons above the regular proportionate quantity; and if mixing the turpentine is commenced too soon, and the pot not sufficiently cool, there will be frequently above a gallon and a half of turpentine lost by evaporation.

All carriage, wainscot, and mahogany varnish ought to have fully one pound of gum for each gallon, when strained and cold; and should one pot require more than its proportion of turpentine, the following pot can easily be left not quite so strongly boiled; then it will require less turpentine to thin it up.

Gold sizes, whether pale or dark, ought to have fully half a pound of good gum copal to each gallon, when it is finished; and the best black japan, to have half a pound of good gum, or upwards, besides the quantity of asphaltum.

Fine mastic, or picture varnish.—Put 5 pounds of fine picked gum mastic into a new four-gallon tin bottle; get ready 2 pounds of glass, bruised as small as barley; wash it several times; afterwards dry it perfectly, and put it into the bottle with 2 gallons of turpentine that has settled some time; put a piece of soft leather under the bung; lay the tin on a sack upon the counter, table, or any thing that stands solid; begin to agitate the tin, smartly rolling it backward and forward, causing the gum, glass, and turpentine, to work as if in a barrel churn for at least 4 hours, when the varnish may be emptied out into any thing sufficiently clean, and large enough to hold it. If the gum is not all dissolved, return the whole into the bottle, and agitate as before, until all the gum is dissolved; then strain it through fine thin muslin into a clean tin bottle: leave it uncorked, so that the air can get in, but no dust; let it stand for 9 months, at least, before it is used; for the longer it is kept, the tougher it will be, and less liable to chill or bloom. To prevent mastic varnish from chilling, boil one quart of river sand with two ounces of pearl-ashes; afterwards wash the sand three or four times with hot water, straining it each time; put the sand on a soup-plate to dry, in an oven; and when it is of a good heat, pour half a pint of hot sand into each gallon of varnish, and shake it well for five minutes; it will soon settle, and carry down the moisture of the gum and turpentine, which is the general cause of mastic varnish chilling on paintings.

Common mastic varnish.—Put as much gum mastic, unpicked, into the gum-pot as may be required, and to every 2¼ pounds of gum pour in 1 gallon of cold turpentine; set the pot over a very moderate fire, and stir it with the stirrer; be careful, when the steam of the turpentine rises near the mouth of the pot, to cover it with the carpet, and carry it out of doors, as the vapor is very apt to catch fire. A few minutes' low heat will perfectly dissolve 8 pounds of gum, which will, with 4 gallons of turpentine, produce, when strained, 4½ gallons of varnish; to which add, while yet hot, 5 pints of pale turpentine varnish, which improves the body and hardness of the mastic varnish.

Crystal varnish, may be made either in the varnish-house, drawing-room, or parlor. Procure a bottle of Canada balsam, which can be had at any druggist's; draw out the cork, and set the bottle of balsam at a little distance from the fire, turning it round several times, until the heat has thinned it; then have something that will hold as much as double the quantity of balsam; carry the balsam from the fire, and, while fluid, mix it with the same quantity of good turpentine, and shake them together until they are well incorporated; in a few days the varnish is fit for use, particularly if it is poured into a half-gallon glass or stone bottle, and kept in a gentle warmth. This varnish is used for maps, prints, charts, drawings, paper ornaments, &c.; and when made upon a larger scale, requires only warming the balsam to mix with the turpentine.

White hard spirit-of-wine varnish.—Put 5 pounds of gum sandarach into a four-gallon tin bottle, with 2 gallons of spirits of wine, 60 over proof, and agitate it until dissolved, exactly as directed for the best mastic varnish, recollecting, if washed glass is used, that it is convenient to dip the bottle containing the gum and spirits into a copperful of hot water every 10 minutes—the bottle to be immersed only 2 minutes at a time—which will greatly assist the dissolving of the gum; but, above all, be careful to keep a firm hold over the cork of the bottle, otherwise the rarefaction will drive the cork out with the force of a shot, and perhaps set fire to the place. The bottle, every time it is heated, ought to be carried away from the fire; the cork should be eased a little, to allow the rarefied air to escape; then driven tight, and the agitation continued in this manner until all the gum is properly dissolved; which is easily known by having an empty tin can to pour the varnish into, until near the last, which is to be poured into a gallon measure. If the gum is not all dissolved, return the whole into the four-gallon tin, and continue the agitation until it is ready to be strained, when every thing ought to be quite ready, and perfectly clean and dry, as oily tins, funnels, strainers, or any thing damp, or even cold weather, will chill and spoil the varnish. After it is strained off, put into the varnish one quart of very pale turpentine varnish, and shake and mix the two well together. Spirit varnishes should be kept well corked; they are fit to use the day after being made.

Brown hard spirit varnish, is made by putting into a bottle 3 pounds of gum sandarach, with 2 pounds of shellac, and 2 gallons of spirits of wine, 60 over proof; proceeding exactly as before directed for the white hard varnish, and agitating it when cold, which requires about 4 hours' time, without any danger of fire; whereas, making any spirit varnish by heat is always attended with danger. No spirit varnish ought to be made either near a fire or by candle light. When this brown hard is strained, add one quart of turpentine varnish, and shake and mix it well: next day it is fit for use.

The *Chinese varnish*, comes from a tree which grows in Cochin-China, China, and Siam. It forms the best of all varnishes.

Gold lacker.—Put into a clean four-gallon tin, 1 pound of ground turmeric, 1½ ounces of powdered gamboge, 3½ pounds of powdered gum sandarach, ¾ of a pound of shellac, and 2 gallons of spirits of wine. After being agitated, dissolved, and strained, add 1 pint of turpentine varnish, well mixed.

Red spirit lacker.

2 gallons of spirits of wine;
1 pound of dragon's blood;
3 pounds of Spanish annotto;
3½ pounds of gum sandarach;
2 pints of turpentine.
Made exactly as the yellow gold lacker.

Pale brass lacker.

2 gallons of spirits of wine;
3 ounces of Cape aloes, cut small;
1 pound of fine pale shellac;
1 ounce gamboge, cut small.
No turpentine varnish. Made exactly as before.

But observe, that those who make lackers, frequently want some paler, and some darker, and sometimes inclining more to the particular tint of certain of the component ingredients. Therefore, if a four-ounce vial of a strong solution of each ingredient be prepared, a lacker of any tint can be produced at any time.

Preparation of linseed oil for making varnishes.—Put 25 gallons of linseed oil into an iron or copper pot that will hold at least 30 gallons; put a fire under, and gradually increase the heat, so that the oil may only simmer, for 2 hours; during that time the greatest part of its moisture evaporates; if any scum arises on the surface, skim it off, and put that aside for inferior purposes. Then increase the fire gradually, and sprinkle in, by a little at a time, 3 lbs. of scale litharge, 3 lbs. of good red lead, and 2 lbs. of Turkey umber, all well dried and free from moisture. If any moist driers are added, they will cause the oil to tumefy; and, at the same time, darken it, causing it to look opaque and thick, ropy and clammy, and hindering it from drying and hardening in proper time; besides, it will lie on the working painting like a piece of bladder skin, and be very apt to rise in blisters. As soon as all the driers are added to the oil, keep quietly stirring the driers from the bottom of the pot; otherwise they will burn, which will cause the oil to blacken and thicken before it is boiled enough. Let the fire be so regulated that the oil shall only boil slowly for three hours from the time all the driers were added; if it then ceases to throw up any scum, and emits little or no smoke, it is necessary to test its temperature by a few quill tops or feathers. Dip a quill top in the oil every two minutes, for when the oil is boiled enough, the quill top will crackle or curl up quite burnt; if so, draw out the fire immediately, and let the oil remain in the pot at least from 10 to 24 hours, or longer if convenient, for the driers settle much sooner when the oil is left to cool in the pot, than when it is immediately taken out.

Poppy oil.—Into four pints of pure soft water, put two ounces of foreign white vitriol; warm the water in a clean copper pan, or glazed earthen jar, until the vitriol is dissolved; pour the mixture into a clean glass or stone bottle, large enough to contain three gallons; then add to the solution of vitriol one gallon and a half of poppy oil, cork and agitate the bottle regularly and smartly for at least two hours; then pour out the contents into a wide earthenware dish: leave it at rest for eight days, when the oil will be clean and brilliant on the surface, and may be taken off with a spoon or flat skimmer, and put up in a glass bottle and exposed to the light, which in a few weeks renders the oil exceedingly limpid and colorless.

Nut-oil, or oil of walnuts, is extracted by expression; and that which is extracted without heat, is certainly the most pale, pure, and nutritive seasoning, and retains an exquisite taste of the fruit. That designed for the arts is of inferior quality, and is plentifully imported to us from France; the heat it undergoes in its torrefaction, previous to its expression, disposes it to dry more quickly than that expressed by the cold process; but, at the same time, the heat, though it frees it from its unctuous quality, gives it more color. When it has been extracted by the cold process, it may be prepared in the same way as directed for the poppy oil.

In the above article I have retained the workmen's names—gum, white vitriol, &c., instead of resin, sulphate of zinc, &c.

VEINS (*Filons*, Fr.; *Gänge*, Germ.), are the fissures or rents in rocks, which are filled with peculiar mineral substances, most commonly metallic ores.

VEIN STONES, or GANGUES, are the mineral substances which accompany, and frequently enclose, the metallic ores.

VELLUM, is a fine sort of PARCHMENT, which see.

VELVET (*Velours*, Fr.; *Sammet*, Germ.), a peculiar stuff, the nature of which is explained under FUSTIAN and TEXTILE FABRICS.

VENETIAN CHALK, is STEATITE.

VENUS, is the mythological name of copper.

VENTILATION, or the renewal of fresh air in stagnant places, is nowhere exhibited to such advantage as in the coal mines of Northumberland and Durham, where Mr. Buddle has carried well nigh to systematic perfection the plan of coursing the air through the winding galleries, originally contrived about the year 1760, by Mr. James Spedding, of Workington, the ablest pitman of his day.[*] He converted the whole of the passages into air-pipes, so to speak, drew the current of air from the downcast pit, then traversed it up and down, and round about, through the several sheaths of the workings, so that no particular gallery was left without a current of air. He thereby succeeded in actually expelling the noxious gases from the mines; those demons, which in Germany, at no remote era, were wont to be combated by the priests with impotent exorcisms or pious frauds. Before Mr. Buddle introduced his improvements, he has known the air to be led through a series of workings, thirty miles long, before it made its exit. There is in every coal mine an experienced corps, called wastemen, because they travel over the waste, or the exhausted regions, who can tell at once, by the whistling sound which the air makes at the crevices in certain partitions and doors, whether the ventilation be in good condition or not. They hear these stoppings begin to *sing* or *call*, as they say, whenever an interruption takes place in any point of the labyrinthian line. Another indication of something being wrong, is when the doors get so heavy, that the boys in attendance upon them find them difficult to shut or open. The instant such a defect is discovered by any one, he cries aloud, "Holloa, there is something wrong—the doors are calling!"

In Mr. Spedding's system, the whole of the return air came in one current to his rarefying furnace (see letter C, *fig.* 1158), whether it was at the explosive point or not. This distribution was often fraught with such danger, that a torrent of water had to be kept in readiness, under the name of the waterfall, to be let down to extinguish the fire in a moment. Many explosions at that time occurred, from the furnaces below, and also down through tubes from the furnaces above-ground.

About the year 1807, Mr. Buddle had his attention intensely occupied with this most important object, and then devised his plan of a divided current, carrying that portion through the active furnace C, *fig.* 1158, and the portion of the air from the *foul* workings of the air which, descending in the downcast pit A, coursed through the *clean* workings, up the dumb furnace D, till it reached a certain elevation in B, the upcast pit, above the fireplace. The pitmen had a great aversion, however, at first, to adopt this plan, as they thought that the current of air, by being split, would lose its ventilating power; but they were, ere long, convinced by Mr. Buddle to the contrary. He divides the main current into two separate streams, at the bottom of the pit A, as shown by darts in the figure; the feathered ones, representing that part of the pit in which the course of the current of air is free from explosive mixture, or does not contain above one thirtieth of carbureted hydrogen, as indicated by its effect upon the flame of a candle. The naked darts denote the portions of the mine where the air, being charged to the firing point, is led off towards D, the dumb furnace, which communicates with the hot upcast shaft, out of reach of the flame, and thence derives its power of draught. By suitable alterations in the stoppings (see the various transverse lines, and the crosses), any portion of the workings may, by the agency of the furnace, be laid out of, or brought within, the course of the vitiated current, at the pleasure of the skilful mine-viewer; so that, if he found it necessary, he could confine, by proper arrangements of his furnace, all the vitiated current to a mere gas-pipe or drift, and direct it wholly through the dumb furnace. During a practice of twenty years, Mr. Buddle has not met with any accident in consequence of a defect in the stoppings preventing the complete division of the air. The engineer has it thus within his power to detach or insulate those portions of the mine in which there is a great exudation of gas, from the rest; and, indeed, he is continually making changes, borrowing and lending currents, so to speak; sometimes laying one division or panel upon the one air-course, and sometimes upon the other, just to suit the immediate emergency. As soon as any district has ceased to be dangerous, by the exhaustion of the gas-blowers, it is transferred from the foul to the pure air course, where gunpowder may be safely used, as also candles, instead of Davy's lamps, which give less light.

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[*] Mining engineers use the term *good pitmen*, as admirals do *good seamen*, to denote a proficient in his calling.

The quantity of air put down into the Wallsend colliery, at the time of the last dreadful accident, 18th June, 1835, was not less than 5000 cubic feet per minute, whence it has been justly inferred that the explosion was caused by the rashness of a wasteman carrying a light through a door into a foul drift.

Till the cutting out of the pillars commences (see the right end of the diagram), the ventilation of the several passages, boards, &c., may be kept perfect, supposing the working extended no further than *a*, or *b*; because, as long as there are pillars standing, every passage may be converted into an air-conduit, for leading a current of air in any direction, either to C, the burning, or D, the dumb furnace. But the first pillar that is removed deranges the ventilation at that spot, and takes away the means of carrying the air into the further recess towards *c*. In taking out the pillars, the miners always work to windward, that is to say, against the stream of air; so that whatever gas may be evolved shall be immediately carried off from the people at work. When a range of pillars has been removed, as at *d*, *e*, *f*, no power remains of dislodging the gas from the section of the mine beyond *a*, *b*; and as the pillars are successively cut away to the left hand of the line *a*, *b*, the size of the *goaf*, or void, is increased. This vacuity is a true gas-holder, or reservoir, continually discharging itself at the points *g*, *h*, *i*, into the circulating current, to be carried off by the gas-pipe drift at the dumb furnace, but not to be suffered ever to come in contact with flame of any description. The next range of working, is the line of pillars to the left of *a*, *b*; the coal having been entirely cleared out of the space to the right, where the place of the pillars is marked by dotted lines. The roof in the waste soon falls down, and gets fractured up to the next seam of coal, called the yard-coal seam, which, abounding in gas, sends it down in large quantities, and keeps the immense gasometer, or goaf below, continually replenished. See STOVE.

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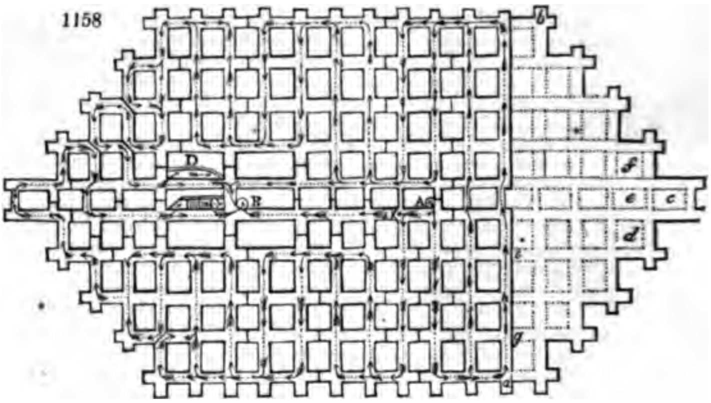

VERATRINE, is a vegetable alkali, of a poisonous nature, extracted from the seeds of the *Veratrum sabadilla*, the roots of the *Veratrum album*, or white hellebore, and of *Colchicum autumnale*, or meadow saffron, in which plants it exists combined chiefly with gallic acid. It is obtained in the form of a white powder. It has an acrid, burning taste, but without any bitterness; it has no smell; but when snuffed into the nostrils, it excites violent and dangerous sneezing. It melts at a heat of 122° F., and concretes, on cooling, into a transparent yellowish mass. It restores the blue color of reddened litmus paper. It is hardly soluble in water or ether, but abundantly in alcohol. It consists of—carbon 66·75, hydrogen 8·54, nitrogen 5·04, and oxygen 19·60. Its saline compounds have an acrid and burning taste. Veratrine resembles strychnine and brucine, in its effects upon living bodies, producing tetanus and death in a moderate dose; notwithstanding which, it has been prescribed by some of our poison doctors, especially mixed with hog's lard, in the form of frictions on the forehead, for nervous maladies; but seldom, I believe, with any good effects.

VERDIGRIS. (*Vert-de-gris*, Fr.; *Grünspan*, Germ.) The copper used in this manufacture, is formed into round sheets, from 20 to 25 inches diameter, by one twenty-fourth of an inch in thickness. Each sheet is then divided into oblong squares, from 4 to 6 inches in length, by 3 broad; and weighing about 4 ounces. They are separately beaten upon an anvil, to smooth their surfaces, to consolidate the metal, and to free it from scales. The refuse of the grapes, after the extraction of their juice, formerly thrown on to the dunghill, is now preserved for the purpose of making verdigris. It is put loosely into earthen vessels, which are usually 16 inches high, 14 in diameter at the widest part, and about 12 at the mouth. The vessels are then covered with lids, which are surrounded by straw mats. In this situation the materials soon become heated, and exhale an acid odor; the fermentation beginning at the bottom of the cask, and gradually rising till it actuate the whole mass. At the end of two or three days, the manufacturer removes the fermenting materials into other vessels, in order to check the process, lest putrefaction should ensue. The copper plates, if new, are now prepared, by rubbing them over with a linen cloth dipped in a solution of verdigris; and they are laid up alongside of one another to dry. If the plates are not subjected to this kind of preparation, they will become black, instead of green, by the first operation. When the plates are ready, and the materials in a fermenting state, one of them is put into the earthen vessel for 24 hours, in order to ascertain whether it be a proper period to proceed to the remaining part of the process. If, at the end of this period, the plate be covered with a uniform green layer, concealing the whole copper, everything is right; but if, on the contrary, liquid drops hang on the surface of the metal, the workmen say the plates are *sweating*, and conclude that the heat of the fermented mass has been inadequate; on which account another day is allowed to pass before making a similar trial. When the materials are finally found to be ready, the strata are formed in the following manner. The plates are laid on a horizontal wooden grating, fixed in the middle of a vat, on whose bottom a pan full of burning charcoal is placed, which heats them to such a degree, that the women who manage this work are obliged to lay hold of them frequently with a cloth when they lift them out. They are in this state put into earthen vessels, in alternate strata with the fermented materials, the uppermost and undermost layers being composed of the expressed grapes. The vessels are covered with their straw mats, and left at rest. From 30 to 40 pounds of copper are put into one vessel.

At the end of 10, 12, 15, or 20 days the vessels are opened, to ascertain, by the materials having become white, if the operation be completed.

Detached glossy crystals will be perceived on the surface of the plates; in which case the grapes are thrown away, and the plates are placed upright in a corner of the verdigris cellar, one against the other, upon pieces of wood laid on the ground. At the end of two or three days they are moistened by dipping in a vessel of water, after which they are replaced in their former situation, where they remain seven or eight days, and are then subjected to momentary immersion, as before. This alternate moistening and exposure to air is performed six or eight times, at regular intervals of about a week. As these plates are sometimes dipped into damaged wine, the workmen term these immersions, *one wine*, *two wines*, &c.

By this treatment, the plates swell, become green, and covered with a stratum of verdigris, which is readily scraped off with a knife. At each operation every vessel yields from five to six pounds of verdigris, in a *fresh* or *humid* state; which is sold to wholesale dealers, who dry it for exportation. For this purpose, they knead the paste in wooden troughs, and then transfer it to leathern bags, a foot and a half long, and ten inches in diameter. These bags are exposed to the sun and air till the verdigris has attained a sufficient degree of hardness. It loses about half its weight in this operation; and it is said to be knife-proof, when this instrument, plunged through the leathern bag, cannot penetrate the loaf of verdigris.

The manufacture of verdigris at Montpellier is altogether domestic. In most wine farm-houses there is a verdigris cellar; and its principal operations are conducted by the females of the family. They consider the forming the strata, and scraping off the verdigris, the most troublesome part. Chaptal says that this mode of making verdigris would admit of some improvements; for example, the acetification requires a warmer temperature than what usually arises in the earthen vessels; and the plates, when set aside to generate the coat of verdigris, require a different degree of heat and moisture from that requisite for the other operations.

Verdigris is a mixture of the crystallized acetate of copper and the sub-acetate, in varying proportions. According to Vauquelin's researches, there are three compounds of oxyde of copper and acetic acid; 1. a subacetate, insoluble in water, but decomposing in that fluid, at common temperatures changing into peroxyde and acetate; 2. a neutral acetate, the solution of which is not altered at common temperatures, but is decomposed by ebullition, becoming peroxyde and superacetate; and, 3. superacetate, which in solution is not decomposed, either at common temperatures or at the boiling point; and which cannot be obtained in crystals, except by slow spontaneous evaporation, in air or *in vacuo*. The first salt, in the dry state, contains 66·51 of oxyde; the second, 44·44; and the third, 33·34.

Mr. Phillips has given the following analyses of French and English verdigris; *Annals of Philosophy*, No. 21.—

	French Verdigris.	English Verdigris.
Acetic acid	29·3	29·62
Peroxyde of copper	43·5	44·25
Water	25·2	25·51
Impurity	2 0	0 62
	100·0	100·00

Distilled verdigris, as it was long erroneously called, is merely a *binacetate* or superacetate of copper, made by dissolving, in a copper kettle, one part of verdigris in two of distilled vinegar; aiding the mutual action by slight heat and agitation with a wooden spatula. When the liquor has taken its utmost depth of color, it is allowed to settle, and the clear portion is decanted off into well-glazed earthen vessels. Fresh vinegar is poured on the residuum, and if its color does not become deep enough, more verdigris is added. The clear and saturated solution is then slowly evaporated, in a vessel kept uniformly filled, till it acquires the consistence of sirup, and shows a pellicle on its surface; when it is transferred into glazed earthen pans, called *oulas* in the country. In each of these dishes, two or three sticks are placed, about a foot long, cleft till within two inches of their upper end, and having the base of the cleft kept asunder by a bit of wood. This kind of pyramid is suspended by its summit in the liquid. All these vessels are transported into crystallizing rooms, moderately heated with a stove, and left in the same state for 15 days, taking care to maintain a uniform temperature. Thus are obtained very fine groups of crystals of acetate of copper, clustered round the wooden rods; on which they are dried, taken off, and sent into the market. They are distinctly rhomboidal in form, and of a lively deep blue color. Each cluster of crystals weighs from five to six pounds; and, in general, their total weight is equal to about one third of the verdigris employed.

The crystallized binacetate of commerce consists, by my analysis, of—acetic acid, 52; oxyde of copper, 39·6; water, 8·4, in 100. I have prepared crystals which contain no water. There is a triple acetate of copper and lime, which resembles distilled verdigris in color. It was manufactured pretty extensively in Scotland some years ago, and fetched a high price, till I published an analysis of it in the Edinburgh Philosophical Journal. It is much inferior, for all uses in the arts, to the proper binacetate.

VERDITER, or BLUE VERDITER. This is a precipitate of oxyde of copper with lime, made by adding that earth, in its purest state, to the solution of nitrate of copper, obtained in quantities by the refiners, in parting gold and silver from copper by nitric acid. The cupreous precipitate must be triturated with lime, after it is nearly dry, to bring out the fine velvety blue color. The process is delicate, and readily misgives in unskilful hands.

The *cendres bleues en pâte* of the French, though analogous, are in some respects a different preparation. To make it, dissolve sulphate of copper in hot water, in such proportions that the liquid may have a density of 1·3. Take 240 pound measures of this solution, and divide it equally into 4 open-headed casks; add to each of these 45 pound measures of a boiling-hot solution of muriate of lime, of specific gravity, 1·317, whereby a double decomposition will ensue; with the formation of muriate of copper and sulphate of lime, which precipitates. It is of consequence to work the materials well together at the moment of mixture, to prevent the precipitate agglomerating in unequal masses. After leaving it to settle for 12 hours, a small quantity of the clear liquor may be examined, to see whether the just proportions of the two salts have been employed, which is done by adding either sulphate of copper or muriate of lime. Should either cause much precipitation, some of the other must be poured in till the equivalent decomposition be accomplished; though less harm results from an excess of sulphate of copper than of muriate of lime.

The muriate of copper is to be decanted from the subsided gypsum, which must be drained and washed in a filter; and these blue liquors are to be added to the stronger; and the whole distributed, as before, into 4 casks; composing in all 670 pound measures of a green liquor, of 1·151 specific gravity.

Meanwhile, a magma of lime is to be prepared as follows:—100 pounds of quicklime are to be mixed up with 300 pounds of water, and the mixture is to be passed through a wire-gauze sieve, to separate the sandy and stony particles, and then to be ground in a proper mill to an impalpable paste. About 70 or 80 pounds of this mixture (the beauty of the color is inversely as the quantity of lime) are to be distributed in equal portions between the four casks, strongly stirring all the time with a wooden spatula. It is then left to settle, and the limpid liquor is tested by ammonia, which ought to occasion only a faint blue tinge; but if the color be deep blue, more of the lime paste must be added. The precipitate is now to be washed by decantation, employing for this purpose the weak washings of a former operation; and it is lastly to be drained and washed on a cloth filter. The proportions of material prescribed above, furnish from 500 to 540 pounds of green paste.

Before making further use of this paste, the quantity of water present in it must be determined by drying 100 or 200 grains. If it contain 27 per cent. of dry matter, 12 pounds of it may be put into a wooden bucket (and more or less in the ratio of 12 to 27 per cent.) capable of containing 17½ pints; a pound (measure) of the lime paste is then to be rapidly mixed into it; immediately afterwards, a pint and a quarter of a watery solution of the pearlash of commerce, of spec. grav. 1·114, previously prepared; and the whole mixture is to be well stirred, and immediately transferred to a color-mill. The quicker this is done, the more beautiful is the shade.

On the other hand, two solutions must have been previously made ready, one of sal-ammoniac (4 oz. troy dissolved in 3½ pints of water), and another of sulphate of copper (8 oz. troy dissolved in 3½ pints of water).

When the paste has come entirely through the mill, it is to be quickly put into a jar, and the two preceding solutions are to be simultaneously poured into it; when a cork is to be inserted, and the jar is to be powerfully agitated. The cork must now be secured with a fat lute. At the end of four days this jar and three of its fellows are to be emptied into a large hogshead nearly full of clear water, and stirred well with a paddle. After repose, the supernatant liquid is run off; when it is filled up again with water, and elutriated several times in succession, till the liquid no longer tinges turmeric paper brown. The deposite may be then drained on a cloth filter. The pigment is sold in the state of a paste; and is used for painting, or printing paper-hangings for the walls of apartments.

The above prescribed proportions furnish the superfine blue paste: for the second quality, one half more quicklime paste is used; and for the third, double of the lime and sal ammoniac; but the mode of preparation is in every case the same.

This paste may be dried into a blue powder, or into crayons for painters, by exposing it on white deals to a very gentle heat in a shady place. This is called *cendres bleues en pierre*.

VERDITER, or BREMEN GREEN. This pigment is a light powder, like magnesia, having a blue or bluish green color. The first is most esteemed. When worked up with oil or glue, it resists the air very well; but when touched with lime, it is easily affected, provided it has not been long and carefully dried. A strong heat deprives it of its lustre, and gives it a brown or blackish-green tint.

The following is, according to M. J. G. Gentele, the process of fabrication in Bremen, Cassel, Eisenach, Minden, &c.:—

a. 225 lbs. of sea salt, and 222 lbs. of blue vitriol, both free from iron, are mixed in the dry state, then reduced between mill-stones with water to a thick homogeneous paste.

b. 225 lbs. of plates of old copper are cut by scissors into bits of an inch square, then thrown and agitated in a wooden tub containing two lbs. of sulphuric acid, diluted with a sufficient quantity of water, for the purpose of separating the impurities; they are afterwards washed with pure water in casks made to revolve upon their axes.

c. The bits of copper being placed in oxydation-chests, along with the magma of common salt and blue vitriol previously prepared in strata of half an inch thick, they are left for some time to their mutual reaction. The above chests are made of oaken planks joined without iron nails, and set aside in a cellar, or other place of moderate temperature.

The saline mixture, which is partially converted into sulphate of soda and chloride of copper, absorbs oxygen from the air, whereby the metallic copper passes into a hydrated oxyde, with a rapidity proportioned to the extent of the surfaces exposed to the atmosphere. In order to increase this exposure, during the three months that the process requires, the whole mass must be turned over once every week, with a copper shovel, transferring it into an empty chest alongside, and then back into the former one.

At the end of three months, the corroded copper scales must be picked out, and the saline particles separated from the slimy oxyde with the help of as little water as possible.

d. This oxydized *schlam*, or mud, is filtered, then thrown, by means of a bucket containing 30 pounds, into a tub, where it is carefully divided or comminuted.

e. For every six pailfuls of *schlam* thus thrown into the large tub, 12 pounds of muriatic acid, at 15° Baumé, are to be added; the mixture is to be stirred, and then left at rest for 24 or 36 hours.

f. Into another tub, called the blue back, there is to be introduced, in like manner, for every six pailfuls of the acidified *schlam*, 15 similar pailfuls of a solution of colorless clear caustic alkali, at 19° Baumé.

g. When the back (*e*) has remained long enough at rest, there is to be poured into it a pail of pure water for every pail of *schlam*.

h. When all is thus prepared, the set of workmen who are to empty the back (*e*), and those who are to stir (*f*), must be placed alongside of each. The first set transfer the *schlam* rapidly into the latter back; where the second set mix and agitate it all the time requisite to convert the mass into a consistent state, and then leave it at rest from 36 to 48 hours.

The whole mass is to be now washed; with which view it is to be stirred about with the affusion of water, allowed to settle, and the supernatant liquor is drawn off. This process is to be repeated till no more traces of potash remain among the blue. The deposite must be then thrown upon a filter, where it is to be kept moist, and exposed freely to the air. The pigment is now squeezed in the filter-bags, cut into bits, and dried in the atmosphere, or at a temperature not exceeding 78° Fahr. It is only after the most complete desiccation that the color acquires its greatest lustre.

VERMICELLI, is a paste of wheat flour, drawn out and dried in slender cylinders, more or less tortuous, like worms, whence the Italian name. The *gruau* of the French is wheat coarsely ground, so as to free it from the husk; the hardest and whitest part, being separated by sifting, is preferred for making the finest bread. When this *gruau* is a little more ground, and the dust separated from it by the bolting-machine, the granular substance called *semoule* is obtained, which is the basis of the best pastes. The softest and purest water is said to be necessary for making the most plastic vermicelli dough; 12 pounds of it being usually added to 50 pounds of *semoule*. It is better to add more *semoule* to the water, than water to the *semoule*, in the act of kneading. The water should be hot, and the dough briskly worked while still warm. The Italians pile one piece of this dough upon another, and then tread it well with their feet for two or three minutes. They afterwards work it for two hours with a powerful rolling-pin, a bar of wood from 10 to 12 feet long, larger at the one end than the other, having a sharp cutting edge at the extremity, attached to the large kneading-trough.

When the dough is properly prepared, it is reduced to thin ribands, cylinders, or tubes, to form vermicelli and macaroni of different kinds. This operation is performed by means of a powerful press. This is vertical, and the iron plate or follower carried by the end of the screw fits exactly into a cast-iron cylinder, called the *bell*, like a sausage-machine, of which the bottom is perforated with small holes, of the shape and size intended for the vermicelli. The *bell* being filled, and warmed with a charcoal fire to thin the dough into a paste, this is forced slowly through the holes, and is immediately cooled and dried by a fanner as it protrudes. When the threads or fillets have acquired the length of a foot, they are grasped by the hand, broken off, and twisted, while still flexible, into any desired shape upon a piece of paper.

The macaroni requires to be made of a less compact dough than the vermicelli. The former is forced through the perforated bottom, usually in fillets, which are afterwards formed into tubes by joining their edges together before they have had time to become dry. The *lazagnes* are macaroni left in the fillet or riband shape.

VERMILION, or *Cinnabar*, is a compound of mercury and sulphur in the proportion of 100 parts of the former to 16 of the latter, which occurs in nature as a common ore of quicksilver, and is prepared by the chemist as a pigment, under the name of Vermilion. It is, properly speaking, a bisulphuret of mercury. This artificial compound being extensively employed, on account of the beauty of its color, in painting, for making red sealing-wax, and other purposes, is the object of an important manufacture. When vermilion is prepared by means of sublimation, it concretes in masses of considerable thickness, concave on one side, convex on the other, of a needle-form texture; brownish-red in the lump, but when reduced to powder, of a lively red color. On exposure to a moderate heat, it evaporates without leaving a residuum, if it be not contaminated with red lead; and at a higher heat, it takes fire, and burns entirely away, with a blue flame.

Holland long kept a monopoly of the manufacture of vermilion, from being alone in possession of the art of giving it a fine flame color. Meanwhile the French chemists examined this product with great care, under an idea that the failure of other nations to rival the Dutch arose from ignorance of its true composition; some, with Berthollet, imagined that it contained a little hydrogen; and others, with Fourcroy, believed that the mercury contained in it was oxydized; but, eventually, Seguin proved that both of these opinions were erroneous; having ascertained, on the one hand, that no hydrogenous matter was given out in the decomposition of cinnabar, and on the other that sulphur and mercury, by combining, were transformed into the red sulphuret in close vessels, without the access of any oxygen whatever. It was likewise supposed that the solution of the problem might be found in the difference of composition between the red and black sulphurets of mercury; and many conjectures were made with this view, the whole of which were refuted by Seguin. He demonstrated, in fact, that a mere change of temperature was sufficient to convert the one sulphuret into the other, without occasioning any variation in the proportion of the two elements. Cinnabar, moderately heated in a glass tube, is convertible into ethiops, which in its turn is changed into cinnabar by exposing the tube to a higher temperature; and thence he was led to conclude that the difference between these two sulphurets was owing principally to the state of the combination of the constituents. It would seem to result, from all these researches, that cinnabar is only an intimate compound of pure sulphur and mercury, in the proportions pointed out by analysis; and it is therefore reasonable to conclude, that in order to make fine vermilion, it should be sufficient to effect the union of its elements at a high enough temperature, and to exclude the influence of all foreign matters; but, notwithstanding these discoveries, the art of making good vermilion is nearly as much a mystery as ever. M. Seguin, indeed, announced in his Memoirs, that he had succeeded in obtaining, in his laboratory, as good a cinnabar as that of Holland, and at a remunerative price; but whatever truth may be in this assertion, or however much the author may have been excited by the love of honor and profit, no manufacture on the great scale sprung up under his auspices. France is still as tributary as ever to foreign nations for this chemical product. At an exposition some years ago, indeed, a sample of good French vermilion was brought forward to prove that the problem was nearly solved; but that it is not so completely, may be inferred from the silence on this subject in M. Dupin's report of the last exposition, in 1834, where we see so many chemical trifles honored with eulogiums and medals by the judges of the show. The English vermilion is now most highly prized by the French manufacturers of sealing-wax.

M. Tuckert, apothecary of the Dutch court, published, long ago, in the *Annales de Chimie*, vol. iv., the best account we yet have of the manufacture of vermilion in Holland; one which has been since verified by M. Payssé, who saw the process practised on the great scale with success.

"The establishment in which I saw, several times, the fabrication of sublimed sulphuret of mercury," says M. Tuckert, "was that of Mr. Brand, at Amsterdam, beyond the gate of Utrecht; it is one of the most considerable in Holland, producing annually, from three furnaces, by means of four workmen, 48,000 pounds of cinnabar, besides other mercurial preparations. The following process is pursued here :—

"The ethiops is first prepared by mixing together 150 pounds of sulphur, with 1080 pounds of pure mercury, and exposing this mixture to a moderate heat in a flat polished iron pot, one foot deep, and two feet and a half in diameter. It never takes fire, provided the workman understands his business. The black sulphuret, thus prepared, is ground, to facilitate the filling with it of small earthen bottles capable of holding about 24 ounces of water; from 30 to 40 of which bottles are filled beforehand, to be ready when wanted.

"Three great subliming pots or vessels, made of very pure clay and sand, have been previously coated over with a proper lute, and allowed to dry slowly. These pots are set upon three furnaces bound with iron hoops, and they are covered with a kind of iron dome. The furnaces are constructed so that the flame may freely circulate and play upon the pots, over two thirds of their height.

"The subliming vessels having been set in their places, a moderate fire is kindled in the evening, which is gradually augmented till the pots become red. A bottle of the black sulphuret is then poured into the first in the series, next into the second and third, in succession; but eventually, two, three, or even more, bottles may be emptied in at once; this circumstance depends on the stronger or weaker combustion of the sulphuret of mercury thus projected. After its introduction, the flame rises 4 and sometimes 6 feet high; when it has diminished a little, the vessels are covered with a plate of iron, a foot square, and an inch and a half thick, made to fit perfectly close. In this manner, the whole materials which have been prepared are introduced, in the course of 34 hours, into the three pots; being for each pot 360 pounds of mercury, and 50 of sulphur; in all, 410 pounds."

The degree of firing is judged of, from time to time, by lifting off the cover; for if the flame rise several feet above the mouth of the pot, the heat is too great; if it be hardly visible, the heat is too low. The proper criterion being a vigorous flame playing a few inches above the vessel. In the last of the 36 hours' process, the mass should be dexterously stirred up every 15 or 20 minutes, to quicken the sublimation. The subliming pots are then allowed to cool, and broken to pieces in order to collect all the vermilion incrusted within them; and which usually amounts to 400 lbs., being a loss of only 60 on each vessel. The lumps are to be ground along with water between horizontal stones, elutriated, passed through sieves, and dried. It is said that the rich tone of the Chinese vermilion may be imitated by adding to the materials for subliming one per cent. of sulphuret of antimony, and by digesting the ground article first in a solution of sulphuret of potassa, and, finally, in diluted muriatic acid.

The humid process of Kirchoff has of late years been so much improved, as to furnish a vermilion quite equal in brilliancy to the Chinese. The following process has been recommended. Mercury is triturated for several hours with sulphur, in the cold, till a perfect ethiops is formed; potash ley is then added, and the trituration is continued for some time. The mixture is now heated in iron vessels, with constant stirring at first, but afterwards only from time to time. The temperature must be kept up as steadily as possible at 130° Fahr., adding fresh supplies of water as it evaporates. When the mixture which was black, becomes, at the end of some hours, brown-red, the greatest caution is requisite, to prevent the temperature from being raised above 114°, and to preserve the mixture quite liquid, while the compound of sulphur and mercury should always be pulverulent. The color becomes red, and brightens in its hue, often with surprising rapidity. When the tint is nearly fine, the process should be continued at a gentler heat, during some hours. Finally, the vermilion is to be elutriated, in order to separate any particles of running mercury. The three ingredients should be very pure. The proportion of product varies with that of the constituents, as we see from the following results of experiments, in which 300 parts of mercury were always employed, and from 400 to 450 of water :—

Sulphur.	Potash.	Vermilion obtained.
114	75	330
115	75	331
120	120	321
150	152	382
120	180	245
100	180	244
80	180	142

The first proportions are therefore the most advantageous; the last, which are those of M. Kirchoff himself, are not so good.

Brunner found that 300 parts of quicksilver, 114 of sulphur, 75 of caustic potassa, and from 400 to 450 of water, form very suitable proportions for the moist process; that the best temperature was 113° F.; and that 122° was the highest limit of heat compatible with the production of a fine color.

The theory of this process is by no means clear. We may suppose that a sulphuret of potassium and mercury is first formed, which is eventually destroyed, in proportion as the oxygen of the air acts upon the sulphuret of potassium itself. There may also be produced some hyposulphite of mercury, which, under the same influence, would be transformed into sulphuret of mercury and sulphate of potash.

Sulphuret of potassium and mercury furnish also vermilion, but it is not beautiful. Red oxyde of mercury, calomel, turbith mineral, and the soluble mercury of Hahnemann, treated with the sulphuret of potassium, or the hydrosulphuret of ammonia, are all capable of giving birth to vermilion by the humid way.

The vermilion of commerce is often adulterated with red lead, brickdust, dragon's blood, and realgar. The first two, not being volatile, remain when the vermilion is heated to its subliming point; the third gives a red tincture to alcohol; the fourth exhales its peculiar garlic smell with heat; and when calcined in a crucible with carbonate of soda, and nitre in excess, affords arsenic acid, which may be detected by the usual chemical tests.

VINEGAR MANUFACTORY, BY MALT. Annual produce, 100,000 gallons.

Expenses for one month.	£	s.	d.
Cost of material and fuel for 8,333 gallons, at 8¾*d*. - -	303	16	2
Wages to 8 workmen, at 25*s*. per week - - - -	40	0	0
Salaries to clerks, manager, and traveller - - - -	83	6	8
Travelling expenses - - - - - - - - -	30	0	0
Three horses' keep - - - - - - - - -	7	10	0
Rent and taxes - - - - - - - - - -	25	0	0
	£489	12	10
Expenses for 5 months, at 489*l*. 12*s* 10*d*. - - - -	2448	4	2
Duty on 41,665 gallons, at 2*d*. - - - - -	347	4	2
Stock of utensils - - - - - - - - -	1500	0	0
	£4295	8	4

Produce of 100,000 gallons, at 1*s.* 8*d.* - - - - - -				£8,333	6	8
Expenses for 12 months, at 489*l.* 12*s.* 10*d.* - -	£5,875	18	0			
Duty on 100,000 gallons, at 2*d.* - - - - -	833	6	8			
Interest on capital, 4,295*l.* 8*s.* 4*d.* - - - - -	214	4	5			
				6,923	9	1
Net profit - - - - - - - - - -				£1,409	17	7

See ACETIC ACID.

VIOLET DYE, is produced by a mixture of red and blue coloring-matters, which are applied in succession. Silk is dyed a fugitive violet with either archil or Brazil wood; but a fine fast violet, first by a crimson with cochineal, without tartar or tin mordant, and after washing, it is dipped in the indigo vat. A finish is sometimes given with archil. A violet is also given to silk, by passing it through a solution of verdigris, then through a bath of logwood, and, lastly, through alum water. A more beautiful violet may be communicated by passing the alumed silk through a bath of Brazil wood, and after washing it in the river, through a bath of archil.

To produce violets on printed calicoes, a dilute acetate of iron is the mordant, and the dye is madder. The mordanted goods should be well dunged.

A good process for dyeing cottons violet, is—first, to gall, with 18 or 20 pounds of nutgalls for every 100 pounds of cotton; second, to pass the stuff, still hot, through a mordant composed of—alum, 10 pounds; iron-liquor, at 1¼° B., and sulphate of copper, each 5 or 6 pounds; water, from 24 to 28 gallons; working it well, with alternate steeping, squeezing, airing, dipping, squeezing, and washing; third, to madder, with its own weight of the root; and fourth, to brighten with soap. If soda be used at the end, instead of soap, the color called *prune de monsieur* will be produced; and by varying the doses of the ingredients, a variety of violet tints may be given.

The best violets are produced by dyeing yarn or cloth which has been prepared with oil as for the Turkey-red process. See MADDER.

For the violet *pruneau*, a little nitrate of iron is mixed with the alum mordant, which makes a black; but this is changed into *violet pruneau*, by a madder bath, followed by a brightening with soap.

VITRIFIABLE COLORS; see ENAMELS, PASTES, POTTERY, and STAINED GLASS.

VITRIOL, from *vitrum*, glass, is the old chemical, and still the vulgar appellation of sulphuric acid, and of many of its compounds, which in certain states have a glassy appearance: thus —

Vitriolic acid, or oil of vitriol, is sulphuric acid; blue vitriol, is sulphate of copper; green vitriol, is green sulphate of iron; vitriol of Mars, is red sulphate of iron; and white vitriol, is sulphate of zinc.

W.

WACKE, is a massive mineral, intermediate between claystone and basalt. It is of a greenish-gray color; vesicular in structure; dull, opaque; streak shining; soft, easily frangible; spec. grav. 2·55 to 2·9; it fuses like basalt.

WADD, is the provincial name of plumbago in Cumberland; and also of an ore of manganese in Derbyshire, which consists of the peroxyde of that metal, associated with nearly its own weight of oxyde of iron.

WADDING (*Ouate*, Fr.; *Watte*, Germ.), is the spongy web which serves to line ladies' pelisses, &c. *Ouate*, or *Wat*, was the name originally given to the glossy downy tufts found in the pods of the plant commonly called *Apocyn*, and by botanists *Asclepias Syriaca*, which was imported from Egypt and Asia Minor for the purpose of stuffing cushions, &c. Wadding is now made with a lap or fleece of cotton prepared by the carding-engine (see *Carding*, COTTON MANUFACTURE), which is applied to tissue paper by a coat of size, made by boiling the cuttings of hare-skins, and adding a little alum to the gelatinous solution. When two laps are glued with their faces together, they form the most downy kind of wadding.

WAFERS. There are two manners of manufacturing wafers: 1, with wheat flour and water, for the ordinary kind; and 2, with gelatine. 1. A certain quantity of fine flour is to be diffused through pure water, and so mixed as to leave no clotty particles. This thin pap is then colored with one or other of the matters to be particularly described under the second head; and which are, vermilion, sulphate of indigo, and gamboge. The pap is not allowed to ferment, but must be employed immediately after it is mixed. For this purpose a tool is employed, consisting of two plates of iron, which come together like pincers or a pair of tongs, leaving a certain small definite space betwixt them. These plates are first slightly heated, greased with butter, filled with the pap, closed, and then exposed for a short time to the heat of a charcoal fire. The iron plates being allowed to cool, on opening them, the thin cake appears dry, solid, brittle, and about as thick as a playing-card. By means of annular punches of different sizes, with sharp edges, the cake is cut into wafers. 2. The transparent wafers are made as follows:—

Dissolve fine glue, or ising-glass, in such a quantity of water, that the solution, when cold, may be consistent. Let it be poured hot upon a plate of mirror glass, (previously warmed with steam, and slightly greased,) which is fitted in a metallic frame, with edges just as high as the wafers should be thick. A second plate of glass, heated and greased, is laid on the surface, so as to touch every point of the gelatine, resting on the edges of the frame. By this pressure, the thin cake of gelatine is made perfectly uniform. When the two plates of glass get cold, the gelatine becomes solid, and may easily be removed. It is then cut with proper punches into discs of different sizes.

The coloring-matters ought not to be of an insalubrious kind.

For red wafers, carmine is well adapted, when they are not to be transparent; but this color is dear, and can be used only for the finer kinds. Instead of it, a decoction of Brazil wood, brightened with a little alum, may be employed.

For yellow, an infusion of saffron or turmeric has been prescribed; but a decoction of weld, fustic, or Persian berries, might be used.

Sulphate of indigo, partially saturated with potash, is used for the blue wafers; and this mixed with yellow, for the greens. Some recommend the sulphate to be nearly neutralized with chalk, and to treat the liquor with alcohol, in order to obtain the best blue dye for wafers.

Common wafers are, nowever, colored with the substances mentioned at the beginning of the article; and for the cheaper kinds, red lead is used instead of vermilion, and turmeric instead of gamboge.

WALNUT HUSKS, or PEELS (*Brout des noix*, Fr.), are much employed by the French dyers for rooting or giving dun colors.

WARP (*Chaine*, Fr.; *Kette*, *Anschweif*, *Zettel*, Germ.), is the name of the longitudinal threads or yarns, whether of cotton, linen, silk, or wool, which being decussated at right angles by the woof or weft threads, form a piece of cloth. The warp yarns are parallel, and continuous from end to end of the web. See Weaving, for a description of the *warping-mill*.

WASH, is the fermented wort of the distiller.

WASHING. See Bleaching, and Scouring.

WATERING OF STUFFS (*Moirage*, Fr.), is a process to which silk and other textile fabrics are subjected, for causing them to exhibit a variety of undulated reflections, and plays of light. It is produced by sprinkling water upon the goods, and then passing them through a calender, either with cold or hot rollers, plain or variously indented.

WATER-PROOF CLOTH. See Caoutchouc, and Gelatine.

A patent was obtained, in August, 1830, by Mr. Thomas Hancock, for rendering textile fabrics impervious to water and air, by spreading the liquid juice of the caoutchouc tree upon the surfaces of the goods, and then exposing them to the air to dry. It does not appear that this project has been realized in our manufactures.

Mr. William Simpson Potter proposes, in his patent of April, 1835, to render fabrics water-proof by imbuing them with a solution of ising-glass, alum, and soap, by means of a brush applied to the wrong side of the cloth, distended upon a table. After it is dry, it must be brushed on the wrong side, against the grain. Then the brush is to be dipped in clean water, and passed lightly over the cloth. The gloss caused by the above application can be taken off by brushing the goods when they are dry. Cloth so prepared is said to be impervious to water, but not to air.

I have examined woollen cloth now on sale in a shop in the Strand, which may be breathed through with the greatest facility, but which retains water upon its surface, as is evinced by a body of water standing upon a concave piece of it tied over a show-glass in the window.

Mr. Sievier's plan of rendering cloth water-proof, for which he obtained a patent in December, 1835, consists in spreading over it, with a brush, a solution of India rubber in spirits of turpentine, at one or more applications, and then applying a similar solution mixed with acetate of lead, litharge, sulphate of zinc, gum mastic, or other drying material. He next takes wool, or other textile material, cut into proper lengths, and spreads it upon the surface of the fabric varnished in this manner, for the purpose of forming the nap or pile. He then presses the cloth by means of rollers, or brushes, so as to fix the nap firmly to its surface.

WATERS, MINERAL.—TABLE I. ANALYSES of the principal MINERAL WATERS of Germany.

Grains of Anhydrous Ingredients in One Pound Troy.	Carlsbad.	ms.	Schlesischer. Obersalz-brunnen.	Marienbad. Kreutzbr.	Auschowitz. Ferdinands-brunnen.	Eger. Franzens-brunnen.	Pyrmont.	Spa. Pouhon.	Fachingen.	Geilnau.	Seltzer.	Seidschutz	Pullna.
Carbonate of Soda..........	7·2712	8·0625	6·1133	5·3499	4·5976	3·8914	-	0·5531	12·3328	4·9658	4·6162		
Ditto of Lithia..............	0·0150	0·0405	0·0127	0·0858	0·0507	0·0282							
Ditto of Baryta..............	-	0·0022	-	-	-	-	-	-	-	-	0·0014		
Ditto of Strontia............	0 0055	0·0080	0·0165	0·0028	0·0040	0·0022	-	-	-	-	0·0144		
Ditto of Lime................	1·7775	0·8555	1·7497	2·9509	3·0085	1·3501	4·7781	0·7387	1·8667	2·2279	1·4004	5·1045	0·5775
Ditto of Magnesia...........	1·0275	0·5915	1·4107	2·0390	2·2867	0·5040	-	0·8421	1·2963	1·6282	1 5000	0·6235	4·8045
Ditto (Proto) of Manganese..	0·0048	0·0028	-	0·0288	0·0692	0·0322	0·0364	0·0389	-	-	-	0·0032	
Ditto (Proto) of Iron........	0·0208	0·0120	0·0480	0·1319	0·2995	0·1762	0·2213	0 2813	-	-	-	0·0095	
Sub-Phosphate of Lime......	0·0012	-	-	-	-	0·0172	-	0·0102	0·0061	-	0·0007	0 0117	0·0026
Ditto of Alumina...........	0·0019	0·0014	0·0045	-	0·0040	0·0092	0·0110	0 0064	-	-	0·0020	0·0068	
Sulphate of Potassa.........	-	0·4050	0·2220	-	-	-	0 0814	0·0592	-	0·2154	0·2978	3·6705	3·6000
Ditto of Soda...............	14·9019	-	2·2095	28·5868	16·9022	18·3785	1·6092	0·0281	0·1267	0·0315	-	17·6220	92·8500
Ditto of Lithia..............	-	-	-	-	-	-	0·0067	-	-	-	-		
Ditto of Lime	-	-	-	-	-	-	5·0265	-	-	-	-	1·1287	1·9500
Ditto of Strontia............	-	-	-	-	-	-	0 0154	-	-	-	-	0·0347	
Ditto of Magnesia...........	-	-	-	-	-	-	2·3664	-	-	-	-	62·3535	69·8145
Nitrate of Magnesia.........	-	-	-	-	-	-	-	-	-	-	-	5·9368	
Chlor. of Potassium..........	-	0·0338	-	-	-	-	-	-	-	-	0 2685		
Ditto of Sodium.............	5·9820	5·7255	0·8752	10·1727	6·7472	6·9229	-	0·3371	2·2337	0·4072	12·9690		
Ditto of Magnesium.........	-	-	-	-	-	-	0·8450	-	-	-	-	1·2225	14·7495
Fluoride of Calcium.........	00·184	0·0014	-	-	-	-	-	-	-	-	0 0013		
Alumina	-	-	-	0·0023	-	-	-	-	-	0·0185			
Silica.......................	0·4329	0·3104	0·2531	0·2908	0·5023	0·3548	0 3727	0·3729	0·0657	0·2021	0·2965	0·0990	0·1390
Total................	31·4606	16·0525	12·9152	49·6417	34·4719	31·6670	15·4221	3·2691	18 9300	9·6966	21·2962	98·0123	188·4906
Carbonic Acid Gas in 100 cubic inches........	56	51	98	105	146	154	160	136	135	163	126	20	7
Temperature (F.).........	Sprud. 165° Neub. 138° Mühl. 128° Ther. 122°	Kess. 117° Krän. 84°	58°	53°	46°	53°	56°	50°	50°	51°	56°	56°	56°
Analyzed by............	Berzelius.	Struve.	Struve.	Berzelius.	Steinmann.	Berzelius.	Struve.	Struve.	Bischoff.	Struve.	Struve.	Struve.	Struve.

TABLE II.—The COMPOSITION of other celebrated MINERAL WATERS.

	Names of the Springs.	Grains of water.	Cubic Inches of Gases.				Carbonates of				Sulphates of				Muriates of				Silica.	Alumina.	Resins.	Temperature.
			Oxygen.	Carbonic acid.	Sulph. hydrogen.	Azote.	Soda.	Lime.	Magnesia.	Iron.	Soda.	Lime.	Magnesia.	Iron.	Soda.	Lime.	Magnesia.	Potash.				
							grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	grs.	
	Kilburn (1)—acidulous	138240	-	84·0	36·0	-	-	2·4	1·25	0·3¼	18·2	13·0	91·0	-	6·0	0·6	2·8	-	-	-	6·0	cold
Sulphurous.	Harrowgate (2)	103643	-	8·0	19 0	7·0	-	18·5	5·5	-	-	-	0·5	-	615·5	3·0	9·1	-	-	-	-	cold
	Moffat (2)	103643	-	1·0	10·0	4·0	-	-	-	-	-	-	-	-	3·6	-	-	-	-	-	-	cold
	Aix-la-Chapelle (3)	8940	-	-	13·06	-	-	15·25	5·89	-	-	-	-	-	6·21	-	-	-	-	-	-	143°
	Enghein (4)	92160	-	18·5	7·0	-	-	21·4	1·35	-	-	33·3	5·8	-	2·4	-	8·0	-	-	-	-	cold
Saline.	Seidlitz	58309	-	8·0	-	-	-	0·7	21·0	-	-	41·1	14·44	-	-	-	36·5	-	-	-	-	cold
	Cheltenham (5)	103643	-	30·3	3·0	12·0	-	-	12·5	5·0	48·0	40·0	-	-	5·0	-	12·5	-	-	-	-	cold
	Plombieres (6)	14600	-	-	-	-	36·0	0·4	-	-	1·0	-	-	-	2·0	-	-	-	-	-	-	cold
	Dunblane (7) sp. gr. 1·00475	7291	-	-	-	-	-	0·5	-	0·17	3·7	-	-	-	21·0	20·8	-	-	-	-	-	cold
	Pitcaithley (7)	7291	-	1·0	-	-	-	0·5	-	-	0·9	-	-	-	12·7	20·2	-	-	-	-	-	cold
Chalybeate.	Tunbridge (3)	103643	1·4	10·6	-	4·0	-	-	-	1·0	-	1·25	-	-	0·5	-	2·25	-	-	-	-	cold
	Brighton (8)	58309	-	18·0	-	-	-	-	-	-	-	32·7	-	11·2	12·2	-	6·0	-	1·12	-	-	cold
	Toplitz (9)	22540	-	-	-	-	13·5	16·5	-	32·5	-	-	-	-	61·3	28.5	-	-	-	15·1	-	cold
Calcareous, nearly pure.	Bath (10)	15360	-	2·4	-	-	-	1·6	-	0·004	3·0	18·0	-	-	6·6	-	-	-	0·4	-	-	114°
	Buxton (11)	58309	-	-	-	2·0	-	10·5	-	-	-	2·5	-	-	1·5	-	-	-	-	-	-	82°
	Bristol (12)	58309	-	30·3	-	-	-	13·5	-	-	11·2	11·7	-	-	4·0	-	7·25	-	-	-	-	74°
	Matlock	58309	-	-	-	-	-	-	-	-	-	trace	-	-	-	-	-	-	-	-	-	66°
	Malvern (13)	58309	-	-	-	-	5·33	1 6	0·92	0·625	2·896	- ·054	-	-	1·55	-	-	-	-	-	-	cold
	Dead Sea (14) sp. gr. 1·211	100	-	-	-	-	-	-	-	-	-		-	-	10·676	3·8	10·1					
	Do. (15) sp. gr. 1·245	-	-	-	-	-	-	-	-	-	-	-	-	-	7·8	10·6	24·2					
	Do. (16) sp. gr. 1·2283	-	-	-	-	-	-	-	-	-	-	-	-	-	6·95	4·0	15·31					
	Sea water, Forth (7)	7291		-	-	-	-	-	-	-	25·6	-	-	-	159·3	5·7	35·5	trace†				

(1) Schmesser.	(4) Fourcroy.	(7) Dr. Murray.	(10) Phillips.	(13) Dr. Philip.	(15) Klaproth.
(2) Garnet.	(5) Fothergill.	(8) Marcet.	(11) Pearson.	(14) Dr. Marcet.	(16) M. Gay Lussac.
(3) Babington.	(6) Vauquelin.	(9) John.	(12) Carrick.	† Dr. Wollaston.	

Mineral waters may, in most cases, be artificially prepared, by the skilful application of the knowledge derived from analysis, with such precision as to imitate very closely the native springs. When the various earthy or metallic constituents are held in solution by carbonic acid, or sulphureted, they should be placed, along with their due proportions of water, in the receiver of the aerating machine (see SODA WATER), and then the proper quantity of gas should be injected into the water. Sufficient agitation will be given by the action of the forcing-pump to promote their solution.

WAX (*Cire*, Fr.; *Wachs*, Germ.), is the substance which forms the cells of bees. It was long supposed to be derived from the pollen of plants, swallowed by these insects, and merely voided under this new form; but it has been proved by the experiments, first of Mr. Hunter, and more especially of M. Huber, to be the peculiar secretion of a certain organ, which forms a part of the small sacs, situated on the sides of the median line of the abdomen of the bee. On raising the lower segments of the abdomen, these sacs may be observed, as also scales or spangles of wax, arranged in pairs upon each segment. There are none, however, under the rings of the males and the queen. Each individual has only eight wax sacs, or pouches; for the first and the last ring are not provided with them. M. Huber satisfied himself by precise experiments that bees, though fed with honey, or sugar alone, produced nevertheless a very considerable quantity of wax; thus proving that they were not mere collectors of this substance from the vegetable kingdom. The pollen of plants serves for the nourishment of the larvæ.

But wax exists also as a vegetable product, and may, in this point of view, be regarded as a concrete fixed oil. It forms a part of the green fecula of many plants, particularly of the cabbage; it may be extracted from the pollen of most flowers; as also from the skins of plums, and many stone fruits. It constitutes a varnish upon the upper surface of the leaves of many trees, and it has been observed in the juice of the *cow-tree*. The berries of the *Myrica angustifolia*, *latifolia*, as well as the *cerifera*, afford abundance of wax.

Bees' wax, as obtained by washing and melting the comb, is yellow. It has a peculiar smell, resembling honey, and derived from it, for the cells in which no honey has been deposited, yield a scentless white wax. Wax is freed from its impurities, and bleached, by melting it with hot water or steam, in a tinned copper or wooden vessel, letting it settle, running off the clear supernatant oily-looking liquid into an oblong trough with a line of holes in its bottom, so as to distribute it upon horizontal wooden cylinders, made to revolve half immersed in cold water, and then exposing the thin ribands or films thus obtained to the blanching action of air, light, and moisture. For this purpose, the ribands are laid upon long webs of canvass stretched horizontally between standards, two feet above the surface of a sheltered field, having a free exposure to the sunbeams. Here they are frequently turned over, then covered by nets to prevent their being blown away by winds, and watered from time to time, like linen upon the grass field in the old method of bleaching. Whenever the color of the wax seems stationary, it is collected, remelted, and thrown again into ribands upon the wet cylinder, in order to expose new surfaces to the blanching operation. By several repetitions of these processes, if the weather proves favorable, the wax eventually loses its yellow tint entirely, and becomes fit for forming white candles. If it be finished under rain, it will become gray on keeping, and also lose in weight.

In France, where the purification of wax is a considerable object of manufacture, about four ounces of cream of tartar, or alum, are added to the water in the first melting-copper, and the solution is incorporated with the wax by diligent manipulation. The whole is left at rest for some time, and then the supernatant wax is run off into a settling cistern, whence it is discharged by a stopcock or tap, over the wooden cylinder revolving at the surface of a large water-cistern, kept cool by passing a stream continually through it.

The bleached wax is finally melted, strained through silk sieves, and then run into circular cavities in a moistened table, to be cast or moulded into thin disc pieces, weighing from two to three ounces each, and three or four inches in diameter.

Neither chlorine, nor even the chlorides of lime and alkalis, can be employed with any advantage to bleach wax, because they render it brittle, and impair its burning quality.

Wax purified, as above, is white and translucent in thin segments; it has neither taste nor smell; it has a specific gravity of from 0·960 to 0·966; it does not liquefy till it be heated to 154½° F.; but it softens at 86°, becoming so plastic, that it may be moulded by the hand into any form. At 32° it is hard and brittle.

It is not a simple substance, but consists of two species of wax, which may be easily separated by boiling alcohol. The resulting solution deposites, on cooling, the waxy body called *cerine*. The undissolved wax, being once and again treated with boiling alcohol, finally affords from 70 to 90 per cent. of its weight of cerine. The insoluble residuum is the *myricine* of Dr. John, so called because it exists in a much larger proportion in the wax of the *Myrica cerifera*. It is greatly denser than wax, being of the same specific gravity as water; and may be distilled without decomposition, which cerine undergoes. See these two articles.

Wax is adulterated sometimes with starch; a fraud easily detected by oil of turpentine, which dissolves the former, and leaves the latter substance; and more frequently with mutton suet. This fraud may be discovered by dry distillation; for wax does not thereby afford, like tallow, sebacic acid (benzoic), which is known by its occasioning a precipitate in a solution of acetate of lead. It is said that two per cent. of a tallow sophistication may be discovered in this way.

Bees' wax imported for home consumption:—in 1835, unbleached, 4,449 cwts.; bleached, 243 cwts.;—in 1836, unbleached, 4,673 cwts.; bleached, 121 cwts. Duty, when from British possessions, 10*s.*; from foreign, 30*s.*

WAX, MINERAL, or *Ozocerite*, is a solid, of a brown color, of various shades, translucent, and fusible like bees' wax; slightly bituminous to the smell, of a foliated texture, a conchoidal fracture, but wanting tenacity, so that it can be pulverized in a mortar. Its specific gravity varies from 0·900 to 0·953. Candles have been made of it in Moldavia, which give a tolerable light. It occurs at the foot of the Carpathians near Slanik, beneath a bed of bituminous slate-clay, in masses of from 80 to 100 pounds weight. Layers of brown amber are found in the neighborhood. It is associated with variegated sandstone, rock salt, and beds of coal (lignite ?). It is analogous to *hatchetine*. Something similar has been discovered in a *trouble* at Urpeth colliery, near Newcastle, 60 fathoms beneath the surface. *Ozocerite* consists of different hydro-carbureted compounds associated together; the whole being composed, ultimately, of—hydrogen 14, carbon 86, very nearly.

WEAVING (*Tissage*, Fr.; *Weberei*, Germ.), is performed by the implement called *loom* in English, *métier à tisser* in French, and *weberstuhl* in German. The process of warping must always precede weaving. Its object is to arrange all the longitudinal threads, which are to form the chain of the web, alongside of each other in one parallel plane. Such a number of bobbins, filled with yarn, must therefore be taken as will furnish the quantity required for the length of the intended piece of cloth. One sixth of that number of bobbins is usually mounted at once in the warp mill, being set loosely in a horizontal direction upon wire skewers, or spindles, in a square frame, so that they may revolve, and give off the yarn freely. The warper sits at A, *fig.* 1159, and causes the reel B to revolve, by turning round with his hand the wheel C, with the endless rope or band D. The bobbins filled with yarn are placed in the frame E. There is a sliding piece at F, called the *heck* box, which rises and falls by the coiling and uncoiling of the cord G, round the central shaft of the reel H. By this simple contrivance, the band of warp-yarns is wound spirally, from top to bottom, upon the reel. I, I, I, are wooden pins which separate the different bands. Most warping mills are of a prismatic form; having twelve, eighteen, or more sides. The reel is commonly about six feet in diameter, and seven feet in height, so as to serve for measuring exactly upon its periphery the total length of the warp. All the threads from the frame E, pass through the heck F, which consists of a series of finely-polished hard-tempered steel pins, with a small hole at the upper part of each, to receive and guide one thread. The heck is divided into two parts, either of which may be lifted by a small handle below, while their eyes are placed alternately. Hence, when one of them is raised a little, a vacuity is formed between the two bands of the warp; but when the other is raised, the vacuity is reversed. In this way, the lease is produced at each end of the warp, and it is preserved by appropriate wooden pegs. The lease being carefully tied up, affords a guide to the weaver for inserting his lease-rods. The warping mill is turned alternately from right to left, and from left to right, till a sufficient number of yarns are coiled round it to form the

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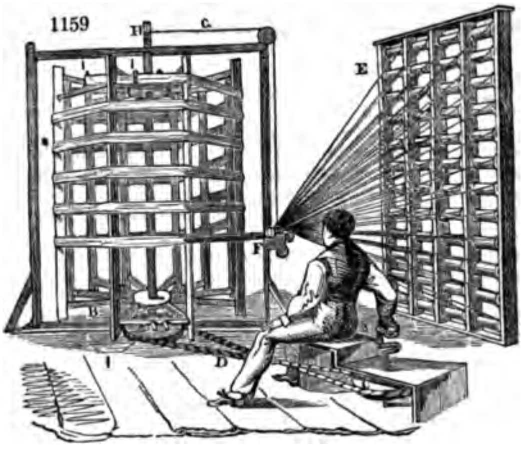
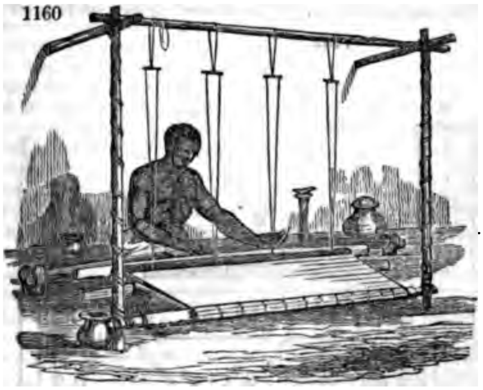


breadth that is wanted; the warper's principal care being to tie immediately every thread as it breaks, otherwise deficiencies would be occasioned in the chain, injurious to the appearance of the web, or productive of much annoyance to the weaver.

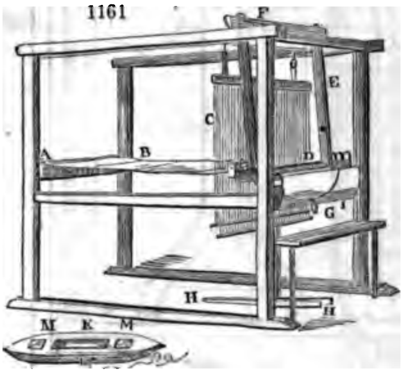
The simplest and probably the most ancient of looms, now to be seen in action, is that of the Hindoo tanty, shown in *fig.* 1160. It consists of two bamboo rollers; one for the warp, and another for the woven cloth; with a pair of heddles, for parting the warp, to permit the weft to be drawn across between its upper and under threads. The shuttle is a slender rod, like a large netting needle, rather longer than the web is broad, and is made use of as a batten or lay, to strike home or condense each successive thread of weft, against the closed fabric. The Hindoo carries this simple implement, with his water pitcher, rice pot, and hooka, to the foot of any tree which can afford him a comfortable shade; he there digs a large hole, to receive his legs, along with the treddles or lower part of the harness; he next extends his warp, by fastening his two bamboo rollers, at a proper distance from each other, with pins, into the sward; he attaches the heddles to a convenient branch of the tree overhead; inserts his great toes into two loops under the gear, to serve him for treddles; lastly, he sheds the warp, draws through the weft, and beats it close up to the web with his rodshuttle or batten.

1160



The European loom is represented in its plainest state, as it has existed for several centuries, in *fig.* 1161. A is the warp-beam, round which the chain has been wound; B represents the flat rods, usually three in number, which pass across between its threads, to preserve the lease, or the plane of decussation for the weft; C shows the heddles or healds, consisting of twines looped in the middle, through which loops the warp yarns are drawn one half through the front heddle, and the other through the back one; by moving which, the decussation is readily effected. The yarns then pass through the dents of the REED under D, which is set in a moveable swing-frame E, called the lathe, lay, and also batten, because it *beats* home the weft to the web. The lay is freely suspended to a cross-bar F, attached by rulers, called the *swords*, to the top of the lateral standards of the loom, so as to oscillate upon it. The weaver, sitting on the bench G, presses down one of the treddles at H, with one of his feet, whereby he raises the corresponding heddle, but sinks the alternate one; thus sheds the warp, by lifting and depressing each alternate thread, through a little space, and opens a pathway or race-course for the shuttle to traverse the middle of the warp, upon its two friction rollers M, M. For this purpose, he lays hold of the picking-peg in his right hand, and, with a smart jerk of his wrist, drives the fly-shuttle swiftly from one side of the loom to the other, between the shed warp yarns. The shoot of weft being thereby left behind from the shuttle pirn or cop, the weaver brings home, by pulling, the lay with its reed towards him by his left hand, with such force as the closeness of the texture requires. The web, as thus woven, is wound up by turning round the cloth beam I, furnished with a ratchet-wheel, which takes into a holding tooth. The plan of throwing the shuttle by the picking-peg and cord, is a great improvement upon the old way of throwing it by hand. It was contrived exactly a century ago, by John Kay, of Bury in Lancashire, but then resident in Colchester, and was called the fly-shuttle, from its speed, as it enabled the weaver to make double the quantity of narrow cloth, and much more broadcloth, in the same time.

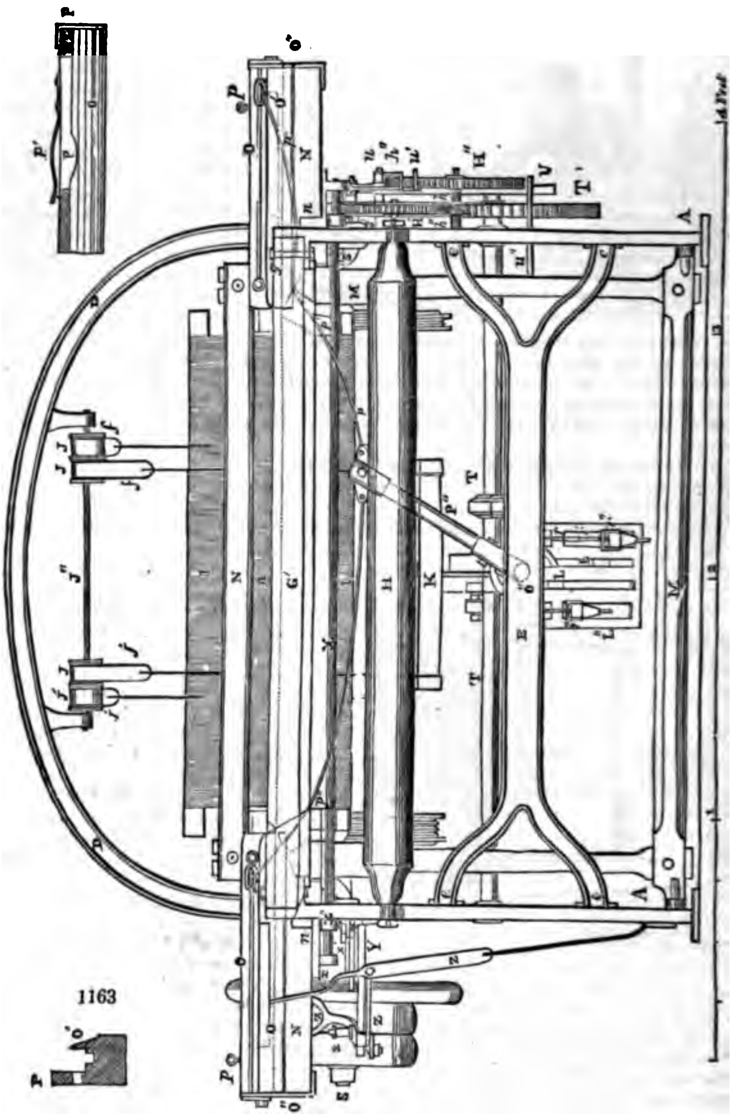
1161



The cloth is kept distended, during the operation of weaving, by means of two pieces of hard wood, called a templet, furnished with sharp iron points in their ends, which take hold of the opposite selvages or lists of the web. The warp and web are kept longitudinally stretched by a weighted cord, which passes round the warp-beam, and which tends continually to draw back the cloth from its beam, where it is held fast by the ratchet teeth. See FUSTIAN, JACQUARD LOOM, REED, and TEXTILE FABRICS.

The greater part of plain weaving, and much even of the figured, is now performed by

1164 1162



the power loom, called *métier mécanique à tisser*, in French. *Fig.* 1162, represents the cast-iron power loom of Sharp and Roberts. A, A′, are the two side uprights, or standards, on the front of the loom. D, is the great arch of cast iron, which binds the two sides together. E, is the front cross-beam, terminating in the forks *e*, *e*; whose ends are bolted to the opposite standards A, A′, so as to bind the framework most firmly together. G′, is the breast beam, of wood, nearly square; its upper surface is sloped a little towards the front, and its edge rounded off, for the web to slide smoothly over it, in its progress to the cloth beam. The beam is supported at its end upon brackets, and is secured by the bolts *g*′, *g*′. H, is the cloth beam, a wooden cylinder, mounted with iron gudgeons at its ends, that on the right hand being prolonged to carry the toothed winding wheel H′. *k*′, is a pinion in gear with H′. H″, is a ratchet wheel, mounted upon the same shaft *h*‴, as the pinion *h*′. *h*′, is the click of the ratchet wheel H″. *h*‴, is a long bolt fixed to the frame, serving as a shaft to the ratchet wheel H″, and the pinion *h*′. I, is the front heddle-leaf, and I′, the back one. J, J, J′, J′, jacks or pulleys and straps, for raising and depressing the leaves of the heddles. J″, is the iron shaft which carries the jacks or system of pulleys J, J, J′, J′. K, a strong wooden ruler, connecting the front heddle with its treddle. L, L′, the front and rear marches or treddle-pieces, for depressing the heddle leaves alternately, by the intervention of the rods *k*, (and *k*′, hid behind *k*). M, M, are the two swords (swing bars) of the lay or batten. N, is the upper cross-bar of the lay, made of wood, and supported upon the squares of the levers *n*, *n*′, to which it is firmly bolted. N′, is the lay-cap, which is placed higher or lower, according to the breadth of the reed; it is the part of the lay which the hand-loom weaver seizes with his hand, in order to swing it towards him. *n*′ is the reed contained between the bar N, and the lay-cap N′. O, O, are two rods of iron, perfectly round and straight, mounted near the ends of the batten-bar N, which serve as guides to the drivers or peckers *o*, *o*, which impel the shuttle. These are made of buffalo hide, and should slide freely on their guide-rods. O′, O′, are the fronts of the shuttle-boxes; they have a slight inclination backwards. P, is the back of them. See *figs*. 1163 and 1164. O″, O″, are iron plates, forming the bottoms of the shuttle-boxes. *p*, small pegs or pins, planted in the posterior faces P (*fig*. 1164) of the boxes, round which the levers P′ turn. These levers are sunk in the substance of the faces P, turn round pegs *p*, being pressed from without inwards, by the springs *p*′. P″, *fig*. 1162, (to the right of K,) is the whip or lever, (and Q″, its centre of motion, corresponding to the right arm and elbow of the weaver,) which serves to throw the shuttle, by means of the pecking-cord *p*″, attached at its other end to the drivers *o*, *o*.

On the axis of Q″, a kind of eccentric or heart wheel is mounted, to whose concave part, the middle of the double band or strap *r*, being attached, receives impulsion; its two ends are attached to the heads of the bolts *r*′, which carry the stirrups *r*″, that may be adjusted at any suitable height, by set screws.

S (see the left-hand side of *fig*. 1162) is the moving shaft, of wrought iron, resting on the two ends of the frame. S′ (see the right-hand side) is a toothed wheel, mounted exteriorly to the frame, upon the end of the shaft S. S″ (near S′) are two equal elbows, in the same direction, and in the same plane, as the shaft S, opposite to the swords M, M, of the lay.

Z, is the loose, and Z′, the fast pulley, or riggers, which receive motion from the steam-shaft of the factory. Z″, a small fly-wheel, to regulate the movements of the main shaft of the loom.

T, is the shaft of the eccentric tappets, cams, or wipers, which press the treddle levers alternately up and down; on its right end is mounted T′, a toothed wheel in gear with the wheel S′, of one half its diameter. T″, is a cleft clamping collar, which serves to support the shaft T.

U, is a lever, which turns round the bolt *u*, as well as the click *h*″. U′, is the click of traction, for turning round the cloth beam, jointed to the upper extremity of the lever U; its tooth *u*′, catches in the teeth of the ratchet wheel H″. *u*″, is a long slender rod, fixed to one of the swords of the lay M, serving to push the lower end of the lever U, when the lay retires towards the heddle leaves.

X, is a wrought-iron shaft, extending from the one shuttle-box to the other, supported at its ends by the bearings *x*, *x*.

Y, is a bearing, affixed exteriorly to the frame, against which the spring bar Z, rests, near its top, but is fixed to the frame at its bottom. The spring falls into a notch in the bar Y, and is thereby held at a distance from the upright A, as long as the band is upon the loose pulley Z′; but when the spring bar is disengaged, it falls towards A, and carries the band upon the fast pulley *z*, so as to put the loom in gear with the steam-shaft of the factory.

Weaving, by this powerful machine, consists of four operations: 1. to shed the warp by means of the heddle leaves, actuated by the tappet wheels upon the axis Q′, the rods *k*, *k*′, the cross-bar E, and the eyes of the heddle leaves I, I′; 2. to throw the shuttle (see *fig*. 1161), by means of the whip lever P″, the driver cord *p*, and the pecker *o*; 3. to drive home the weft by the batten N, N′; 4. to unwind the chain from the warp beam, and to draw it progressively forwards, and wind the finished web upon the cloth beam H, by the click and toothed wheel mechanism at the right-hand side of the frame. For more minute details, the reader may consult *The Cotton Manufacture of Great Britain*, vol. ii. p. 291.

WEFT (*Trame*, Fr.; *Eintrag*, Germ.), is the name of the yarns or threads which run from selvage to selvage in a web.

WELD (*Vouëde*, Fr.; *Wau*, *Gelbkraut*, Germ.), is an annual herbaceous plant, which grows all over Europe, called by botanists *Reseda luteola*. The stems and the leaves dye yellow; and among the dyes of organic nature, they rank next to the Persian berry for the beauty and fastness of color. The whole plant is cropped when in seed, at which period its dyeing power is greatest; and after being simply dried, is brought into the market.

Chevreul has discovered a yellow coloring principle in weld, which he has called *luteoline*. It may be sublimed, and thus obtained in long needle-form, transparent, yellow crystals. Luteoline is but sparingly soluble in water; but it nevertheless dyes alumed silk and wool of a fine jonquil color. It is soluble in alcohol and ether; it combines with acids, and especially with bases.

When weld is to be employed in the dye-bath, it should be boiled for three quarters of an hour; after which the exhausted plant is taken out, because it occupies too much room. The decoction is rapidly decomposed in the air, and ought therefore to be made only when it is wanted. It produces, with

Solution of ising-glass - - - -	a slight turbidity.	
Litmus paper - - - - -	a faint reddening.	
Potash ley - - - - - -	a golden yellow tint.	
Solution of alum - - - - -	a faint yellow.	
Protoxyde salts of tin - - - -	a rich yellow	precipitation.
Acetate of lead - - - - -	ditto	
Salts of copper - - - - -	a dirty yellow-brown	
Sulphate of red oxyde of iron - - -	a brown, passing into olive.	

A lack is made from decoction of weld with alum, precipitated by carbonate of soda or potassa. See Yellow Dye.

WELDING (*Souder*, Fr.; *Schweissen*, Germ.), is the property which pieces of wrought iron possess, when heated to whiteness, of uniting intimately and permanently under the hammer, into one body, without any appearance of junction. The welding temperature is usually estimated at from 60° to 90° of Wedgewood. When a skilful blacksmith is about to perform the welding operation, he watches minutely the effect of the heat in his forge-fire upon the two iron bars; and if he perceives them beginning to burn, he pulls them out, rolls them in sand, which forms a glassy silicate of iron upon the surface, so as to prevent further oxydizement; and then laying the one properly upon the other, he incorporates them by his right-hand hammer, being assisted by another workman, who strikes the metal at the same time with a heavy forge-hammer.

Platinum is not susceptible of being welded, as many chemical authors have erroneously asserted.

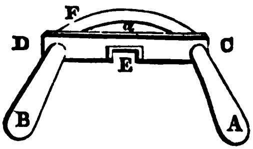
Mr. T. H. Russell, of Handsworth, near Birmingham, obtained a patent, in May, 1836, for manufacturing welded iron tubes, by drawing or passing the skelp, or fillet of sheet iron, five feet long, between dies or holes, formed by a pair of grooved rollers, placed with their sides contiguous; for which process, he does not previously turn up the skelp from end to end, but he does this so as to bring the edges together at the time when the welding is performed. He draws the skelp through two or more pairs of the above pincers or dies, each of less dimension than the preceding. In making tubes of an inch of internal diameter, a skelp four inches and a half broad is employed. The twin rollers revolve on vertical axes, which may be made to approach each other to give pressure; and they are kept cool by a stream of water, while the skelp, ignited to the welding heat, is passed between them. They are affixed at about a foot in front of the mouth of the furnace, on a draw-bench; there being a suitable stop within a few inches of the rollers, against which the workman may place a pair of pincers, having a bell-mouthed hole or die, for welding and shaping the tube. In the first passage between the rollers, a circular revolving plate of iron is let down vertically between them, to prevent the edges of the skelp from overlapping, or even meeting. The welding is performed at the last passage.

WELLS, ARTESIAN. See also Artesian Wells. The following account of a successful operation of this kind, lately performed at Mortlake, in Surrey, deserves to be recorded. The spot at which this undertaking was begun, is within 100 feet of the Thames. In the first instance, an auger, seven inches in diameter, was used in penetrating 20 feet of superficial detritus, and 200 feet of London clay. An iron tube, 8 inches in diameter, was then driven into the opening, to dam out the land-springs and the percolation from the river. A 4-inch auger was next introduced through the iron tube, and the boring was continued until, the London clay having been perforated to the depth of 240 feet, the sands of the plastic clay were reached, and water of the softest and purest nature was obtained; but the supply was not sufficient, and it did not rise the surface. The work was proceeded with accordingly; and after 55 feet of alternating beds of sand and clay had been penetrated, the chalk was touched upon. A second tube, 4½ inches in diameter, was then driven into the chalk, to stop out the water of the plastic sands; and through this tube an auger, 3½ inches in diameter, was introduced, and worked down through 35 feet of hard chalk, abounding with flints. To this succeeded a bed of soft chalk, into which the instrument suddenly penetrated to the depth of 15 feet. On the auger being withdrawn, water gradually rose to the surface, and overflowed. The expense of the work did not exceed 300*l.* The general summary of the strata penetrated is as follows:—Gravel, 20 feet; London clay, 250; plastic sands and clays, 55; hard chalk with flints, 35; soft chalk, 15;=375 feet.

WHALEBONE (*Baleine*, Fr.; *Fischbeine*, Germ.), is the name of the horny laminæ, consisting of fibres laid lengthwise, found in the mouth of the whale, which, by the fringes upon their edges, enable the animal to allow the water to flow out, as through rows of teeth (which it wants), from between its capacious jaws, but to catch and detain the minute creatures upon which it feeds. The fibres of whalebone have little lateral cohesion, as they are not transversely decussated, and may, therefore, be readily detached in the form of long filaments or bristles. The *blades*, or scythe-shaped plates, are externally compact, smooth, and susceptible of a good polish. They are connected, in a parallel series, by what is called the *gum* of the animal, and are arranged along each side of its mouth, to the number of about 300. The length of the longest *blade*, which is usually found near the middle of the series, is the gauge adopted by the fishermen to designate the size of the fish. The greatest length hitherto known has been 15 feet, but it rarely exceeds 12 or 13. The breadth, at the root end, is from 10 to 12 inches; and the average thickness, from four to five tenths of an inch. The series, viewed altogether in the mouth of the whale, resemble, in general form, the roof of a house. They are cleansed and softened before cutting, by boiling for two hours in a long copper.

Whalebone, as brought from Greenland, is commonly divided into portable junks or pieces, comprising ten or twelve blades in each; but it is occasionally subdivided into separate blades, the gum and the hairy fringes having been removed by the sailors during the voyage. The price of whalebone fluctuates from 50*l.* to 150*l.* per ton. The blade is cut into parallel prismatic slips, as follows:—It is clamped horizontally, with its edge up and down, in the large wooden vice of a carpenter's bench, and is then planed by the following tool: *fig.* 1165, A, B, are its two handles; C, D, is an iron plate, with a guide-notch E; F, is a semicircular knife, screwed firmly at each end to the ends of the iron plate C, D, having its cutting edge adjusted in a plane, so much lower than the bottom of the notch E, as the thickness of the whalebone slip is intended to be; for different thicknesses, the knife may be set by the screws at different levels, but always in a plane parallel to the lower guide surface of the plate C, D. The workman, taking hold of the handles A, B, applies the notch of the tool at the end of the whalebone blade furthest from him, and with his two hands pulls it steadily along, so as to shave off a slice in the direction of the fibres; being careful to cut none of them across. These prismatic slips are then dried, and planed level upon their other two surfaces. The fibrous matter detached in this operation, is used, instead of hair, for stuffing mattresses.

1165



From its flexibility, strength, elasticity, and lightness, whalebone is employed for many purposes: for ribs to umbrellas or parasols; for stiffening stays; for the frame-work of hats, &c. When heated by steam, or a sand-bath, it softens, and may be bent or moulded, like horn, into various shapes, which it retains, if cooled under compression. In this way, snuff-boxes, and knobs of walking-sticks, may be made from the thicker parts of the blade. The surface is polished at first with ground pumice-stone, felt, and water; and finished with dry quicklime, spontaneously slaked, and sifted.

WHEAT. (*Triticum vulgare*, Linn.; *Froment*, Fr.; *Waizen*, Germ.) See BREAD, GLUTEN, and STARCH.

WHEEL CARRIAGES. Though this manufacture belongs most properly to a treatise upon mechanical engineering, I shall endeavor to describe the parts of a carriage, so as to enable gentlemen to judge of its make and relative merits. The external form may vary with every freak of fashion; but the general structure of a vehicle, as to lightness, elegance, and strength, may be judged of from the following figure and description.

Fig. 1166, shows the body of a chariot, hung upon an iron carriage, with iron wheels, axletrees, and boxes; the latter, by a simple contrivance, is close at the out-head, by which means the oil cannot escape; and the fastening of the wheel being at the in-head, as will be explained afterwards, gives great security, and prevents the possibility of the wheel being taken off by any other carriage running against it.

Fig. 1167, shows the arm of an axletree, turned perfectly true, with two collars in the solid, as seen at G and H. The parts from G to B are made cylindrical. At K is a screw nail, the purpose of which will be explained in *fig.* 1171.

1166

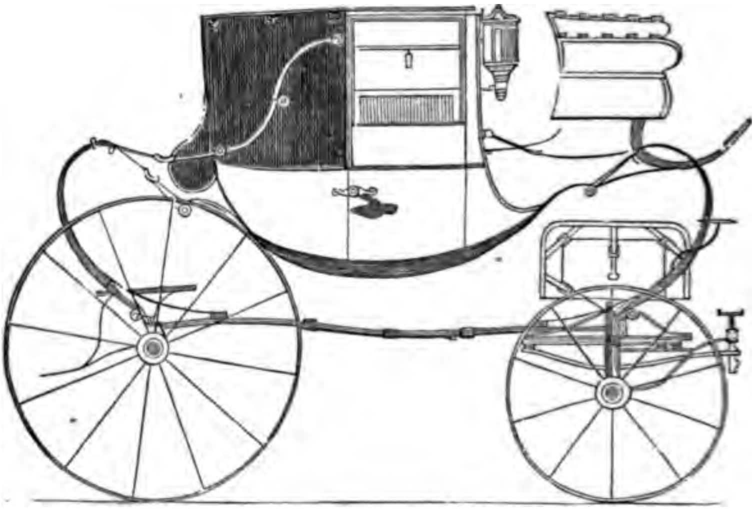


Fig. 1168, is the longitudinal section of a metal nave, which also forms the bush, for the better fitting of which to the axletree, it is bored out of the solid, and made quite air-tight upon the pin; and for retaining the oil, it is left close at the out-head D.

Fig. 1169, represents a collet, made of metal, turned perfectly true, the least diameter of which is made the same with that part of the axletree M, *fig.* 1167, and its greatest diameter the same with that of the solid collar G, *fig.* 1167. This collet is made with a joint at S, and opens at *p*. Two grooves are represented at *qq*, *qq*, which are seen at the same letters in *fig.* 1170, as also the dovetail *r*, in both figures.

Fig. 1170, is an edge view of the collet, *fig.* 1169.

Fig. 1171, is a longitudinal section of an axletree arm, nave or bush, and fastening. A, B, is the arm of the axletree, bored up the centre from B to E. C, C, D, the nave, which

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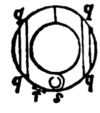

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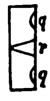

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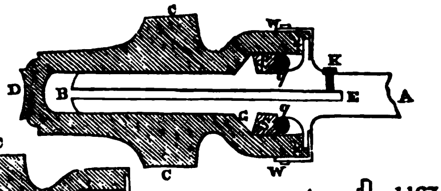

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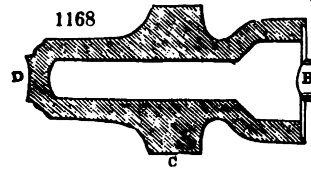

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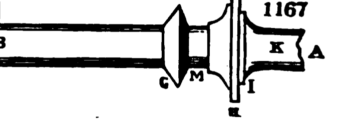


answers also for the bush. P, S, the collet (see *figs.* 1169 and 1170), put into its place. *q*, *q*, two steel pins, passing through the in-head of the bush, and filling up the grooves in the collet. W, W, a caped hoop, sufficiently broad to cover the ends of said pins, and made fast to the bush by screws. This hoop, when so fastened to the bush, prevents the possibility of the pins *q*, *q*, from getting out of their places. *x*, *x*, is a leather washer, interposed betwixt the in-head of the bush and the larger solid collar of the axletree, to prevent the escape of oil at the in-head. K, is a screw, the head of which is near the letter K, in *fig.* 1167. This screw being undone, and oil poured into the hole, it flows down the bore in the centre of the axletree arm, and fills the space B, left by the arm, being about one inch shorter than the bore of the bush, and the screw, being afterwards replaced, keeps all tight. In putting on the wheel, a little oil ought to be put into the space betwixt the collet P, S, and the larger collar. The collar P, S, being moveable round the axletree arm, and being made fast to the bush by means of the two pins *q*, *q*, revolves along with the bush, acting against the solid collar G, of the arm, and keeps the wheel fast to the axletree, until by removing the caped hoop W, W, and driving out the pins *q*, *q*, the collet becomes disengaged from the bush.

The dovetail, seen upon the collet at *r*, *fig.* 1170, has a corresponding groove cut in the bush, to receive it, in consequence of which the wheel must of necessity be put on so that the collet and pins fit exactly. These wheels very rarely require to be taken off, and they will run a thousand miles without requiring fresh oiling.

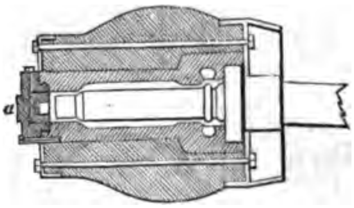
The spokes of the wheel, made of malleable iron, are screwed into the bush or nave at C, C, *figs.* 1168, 1171, all round. The felloes, composed merely of two bars of iron, bent into a circle edgeways, are put on, the one on the front, the other on the back, of the spokes, which have shoulders on both sides to support the felloes, and all three are attached together by rivets through them. The space between the two iron rings forming the felloes, should be filled up with light wood, the tire then put on, and fastened to the felloes by bolts and glands clasping both felloes.

This is a carriage without a mortise or tenon, or wooden joint of any kind. It is, at an average, one seventh lighter than any of those built on the ordinary construction.

The design of Mr. W. Mason's patent invention, of 1827, is to give any required pressure to the ends of what are called mail axletrees, in order to prevent their shaking in the boxes of the wheels. This object is effected by the introduction of leather collars in certain parts of the box, and by a contrivance, in which the outer cap is screwed up, so as to bear against the end of the axletree with any degree of tightness, and is held in that situation, without the possibility of turning round, or allowing the axletree to become loose.

Fig. 1172, shows the section of the box of a wheel, with the end of the axletree secured in it. The general form of the box, and of the axle, is the same as other mail axles, there being recesses in the box for the reception of oil. At the end of the axle, a cap *a*, is inserted, with a leather collar enclosed in it, bearing against the end of the axle; which cap, when screwed up sufficiently tight, is held in that situation by a pin or screw passed through the cap *a*, into the end of the iron box; a representation of this end of the iron box being shown at *fig.* 1173.

1172



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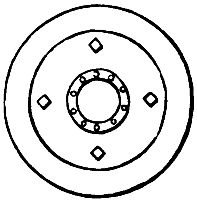


In the cap *a*, there is also a groove for conducting the oil to the interior of the box, with a screw at the opening, to prevent it running out as the wheel goes round.

The particular claims of improvement are, the leather collar against the end of the axle; the pin going through one of the holes in the end of the box, to fix it; and the channel for conducting the oil.

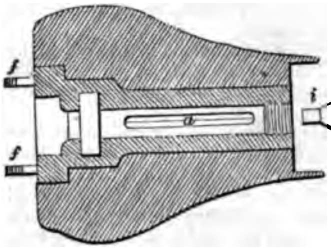
Mr. Mason's patent, of August, 1830, applies also to the boxes and axles of that construction of carriage wheels which are fitted with the so called mail-boxes; but part of the invention applies to other axles.

Fig. 1174, represents the nave of a wheel, with the box for the axle within it, both shown in section longitudinally; *fig.* 1175, is a section of the axle, taken in the same direction; and *fig.* 1176, represents the screw cap and oil-box, which attaches to the outer extremity of the axle-box. Supposing the parts were put together, that is, the axle inserted into the box, then the intention of the different parts will be perceived.

The cylindrical recess *a*, in the box of the nave, is designed to fit the cylindrical part of the axle *b*; and the conical part *c*, of the axle, to shoulder up against a corresponding conical cavity in the box, with a washer of leather to prevent its shaking. A collar *d*, formed by a metallic ring, fits loosely upon a cylindrical part of the axle, and is kept there by a flange or rim, fixed behind the cone *c*. Several strong pins *f*, *f*, are cast into the back part of the box; which pins, when the wheel is attached, pass through corresponding holes in the collar *d*; and nuts being screwed on to the ends of the pins *f*, behind the collar, keep the wheel securely attached to the axle. The screw-cap *g*, is then inserted into the recess *h*, at the outer part of the box, its conical end and small tube *i*, passing into the recess *k*, in the end of the axle.

The parts being thus connected, the oil contained within the cap *g*, will flow through the small tube *i*, in its end, into the recess or cylindrical channel *l*, within the axle, and will thence pass through a small hole in the side of the axle, into the cylindrical recess *a*, of the box; and then lodging in the groove and other cavities within the box, will lubricate the axle as the wheel goes round. There is also a small groove cut on the outside of the axle, for conducting the oil, in order that it may be more equally distributed over the surface and the bearings. This construction of the box and axle, as far as the lubrication goes, may be applied to the axles of wheels in general; but that part of the invention which is designed to give greater security in the attachment of the wheel to the carriage, applies particularly to mail axles.

1174



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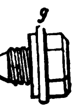

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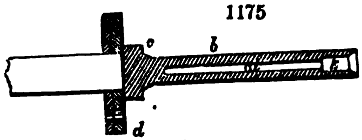

Mr. William Mason's patent invention for wheel carriages, of August, 1831, will be understood by reference to the annexed figures. *Fig.* 1177, is a plan showing the fore-axletree bed *a*, *a*, of a four-wheeled carriage, to which the axletrees *b*, *b*, are jointed at each end; *fig.* 1178 is an enlarged plan; and *fig.* 1179 an elevation, or side view of one end of the said fore-axletree bed, having a Collinge's axletree jointed to the axletree bed, by means of the cylindrical pin or bolt *c*, which passes through and turns in a cylindrical hole *d*, formed at the end of the axletree bed, shown also in the plan view, *fig.* 1180, and section, *fig.* 1181.

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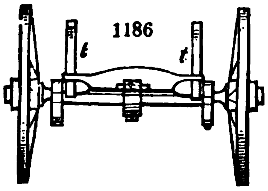

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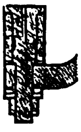

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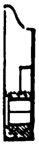

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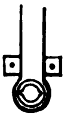

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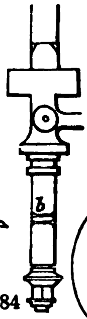

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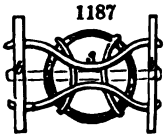

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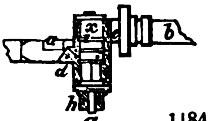

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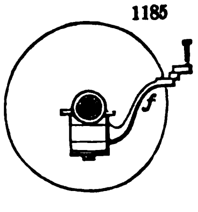
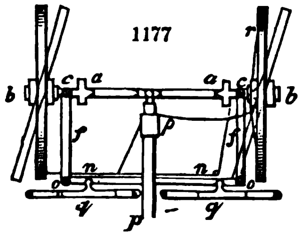


1177



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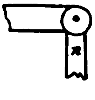

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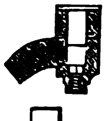

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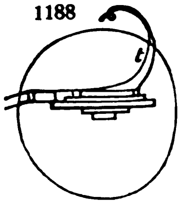

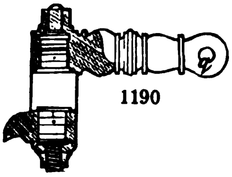

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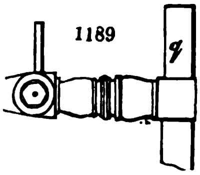


The axletree *b*, is firmly united with the upper end *e*, of the pin or bolt *c*; and to the lower end of it, which is squared, the guide piece *f*, is also fitted, and secured by the screw *g*, and cap or nut *h*, seen in *fig.* 1179, and in section in *fig.* 1182. There are leather washers *i*, *i*, let into recesses made to receive them in the parts *a*, *b*, and *f*, the intent of which is to prevent the oil from escaping that is introduced through the central perpendicular hole seen in *fig.* 1182, which hole is closed by means of a screw inserted into it. The oil is diffused, or spread over the surface of the cylinder *c*, by means of a side branch leading from the bottom of the hole into a groove formed around the cylinder, and also by means of two longitudinal gaps or cavities made within the hole, as shown in *figs.* 1180, and 1181. The guide piece *f*, is affixed at right angles with the axletree *b*, as shown in *fig.* 1178, and turns freely and steadily in the cylindrical hole *d*, made to receive one end of the iron fore-axletree bed *a*. In like manner, the opposite fore axletree *b*, *fig.* 1177, is jointed to the other end of the iron fore-axletree bed.

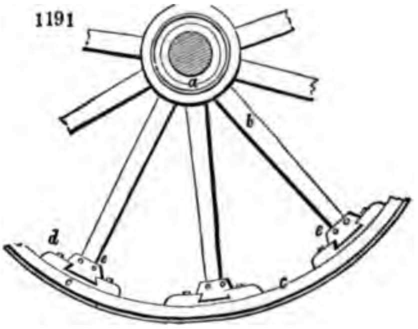
The outer ends of the guide pieces *f*, *f*, are jointed to the splinter-bar *n*, *fig.* 1181, as follows:—*Fig.* 1183, is a plan, and *fig.* 1184, a section of the joint *o*, in *fig.* 1177, shown on an enlarged scale; a cylindrical pin or bolt *c*, is firmly secured in the splinter-bar, and round the lower part of the said pin or bolt the guide piece *f*, turns, and is made fast in its place by the screw *g*, and screwed nut *h*.

Oil is conveyed to the lower part of the cylindrical pin *c*, in a similar manner to that already described, and two leather washers are likewise furnished, to prevent its escape. The connecting joint at the opposite end of the splinter bar *n*, is constructed in a similar manner. The futchel or socket *p*, *p*, for the pole of the carriage, must also be jointed to the middle of the fore-axletree bed and splinter-bar, in a similar manner. The swingletrees *q*, *q*, *fig.* 1177, are likewise jointed in the same way to the splinter-bar. *Fig.* 1185, is a side view of these parts. The fore wheels of the carriage, *fig.* 1177, are furnished with cast-iron boxes, as usual. The dotted lines show the action of the pole *p*, *p*, upon the splinter-bar *n*, and as communicated through the latter to the guide pieces *f*, *f*, connected with the axletrees *b*, *b*, so as to lock the wheels *r*, *r*, as shown in that figure.

The axletree may be incased in the woodwork of the fore-bed of the carriage, as usual, and as shown by dotted lines in the back end view thereof, *fig.* 1186; and the framing *s*, *fig.* 1187, may be affixed firmly upon the said woodwork, in any fit and proper manner, as well as the fore-springs *t*, *t*, shown in *figs.* 1186 and 1187, and likewise in the side view, *fig.* 1188. In certain cases it may be desirable to fix the cylindrical pin or bolt *c*, firmly in the splinter-bar *n*, in the manner shown in *figs.* 1189 and 1190; the swingletrees *q*, *q*, and guide pieces *f*, *f*, turning freely above and below upon the said pin or bolt, and secured in their places thereon by screws and screwed nuts, oil being also supplied through holes formed in both ends of the said pin or bolt, and leather washers provided, as in the above-described instances.

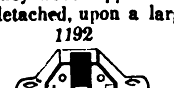
Mr. Gibbs, engineer, and Mr. Chaplin, coach-maker, obtained a patent, in 1832, for the construction of a four-wheeled carriage which shall be enabled to turn within a small compass, by throwing the axles of all the four wheels simultaneously into different positions. They effect this object by mounting each wheel upon a separate jointed axle, and by connecting the free ends of the four axles by jointed rods or chains, with the pole and splinter-bar in front of the carriage.

1191



To fix the ends of the spokes of wheels to the felloe or rim, with greater security than had been effected by previous methods, is the object of a contrivance for which William Howard obtained a patent, in February, 1830. *Fig.* 1191 shows a portion of a wheel constructed on this new method; *a*, is the nave, of wood; *b*, *b*, *b*, wooden spokes, inserted into the nave in the usual way; *c*, *c*, is the rim or felloe, intended to be formed by one entire circle of wrought iron; *d*, and *e*, *e*, are the shoes or blocks, of cast iron, for receiving the ends of the spokes, which are secured by bolts to the rim on the inner circumference. The cap of the block *d*, is removed, for the purpose of showing the internal form of the block; *e*, *e*, have their caps fixed on, as they would appear when the spokes are fitted in. One of the caps or shoes is shown detached, upon a larger scale, at *fig.* 1192, by which it will be perceived that the end of the spoke is introduced into the shoe on the side. It is proposed that the end of the spoke shall not reach quite to the end of the recess formed in the block, and that it shall be made tight by a wedge driven in. The wedge piece is to be of wood, as *fig.* 1193, with a small slip of iron within it; and a hole is perforated in the back of the block or shoe, for the wedge to be driven through. When this is done, the ends of the spokes become confined and tight; and the projecting extremities of the wedges being cut off, the caps are then attached on the face of the block, as at *e*, *e*, by pins riveted at their ends, which secures the spokes, and renders it impossible for them to be loosened by the vibrations as the wheel passes over the ground. One important use of the wedges, is to correct the eccentric figure of the wheel, which may be readily forced out in any part that may be out of the true form, by driving the wedge up further; and this, it is considered, will be a very important advantage, as the nearer a wheel can be brought to a true circle, the easier it will run upon the road. The periphery of the wheel is to be protected by a tire,

1192



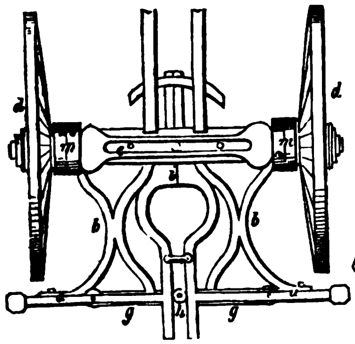
1193

which may be put on in pieces, and bolted through the felloe; or it may be made in one ring, and attached, while hot, in the usual way.

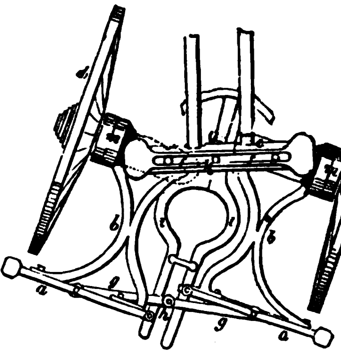
Mr. Reedhead's patent improvements in the construction of carriages, are represented in the following figures. They were specified in July, 1833.

Fig. 1194, is a plan or horizontal view of the fore part of a carriage, intended to be drawn by horses, showing the fore wheels in their position when running in a straight course; *fig.* 1195, is a similar view, showing the wheels as locked, when in the act of turning; *fig.* 1196, is a front end elevation of the same; *fig.* 1197, is a section taken through the centre of the fore axletree; and *fig.* 1198, is a side elevation of the general appearance of a stage-coach, with the improvements appended: *a*, *a*, are two splinter-bars, with their roller-bolts, for connecting the traces of the harness; these splinter-bars are attached, by the bent irons *b*, *b*, to two short axletrees or axle-boxes *c*, *c*, which carry the axles of the fore wheels *d*, *d*, and turn upon vertical pins or bolts *e*, *e*, passed through the fore axletree *f*, the splinter-bars and axle-boxes being mounted so as to move parallel to each other, the latter partaking of any motion given to the splinter-bars by the horses in drawing the carriage forward, and thereby producing the locking of the wheels, as shown in *fig.* 1195; and in order that the two wheels, and their axles and axle-boxes, together with the splinter-bars *a*, *a*, may move simultaneously, the latter are connected by pivots to the end of the links or levers *g*, *g*, which are attached to the arms *i*, *i*, which receive the pole of the coach by a hinge-joint or pin *h*; the arms *i*, *i*, turning on a vertical fulcrum-pin *k*, passed through the main axletree *f*, as the pole is moved from one side to the other.

1194

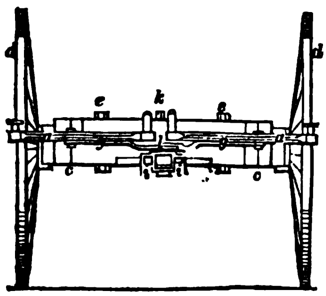


1195



The axles *o*, *o*, are firmly fixed into the naves of the wheels, as represented in the side view of a wheel detached, at *fig.* 1200, the axles being mounted so as to revolve within their boxes in the following manner:— The axle-boxes, which answer the purpose of short axletrees, are formed of iron, and consist of one main or bottom plate *l*, seen best in *figs.* 1200 and 1199; upon this bottom plate is formed the chamber *m*, *m*, carrying the two anti-friction rollers *n*, *n*, which turn on short axles passed through the sides and partition at the upper part of the chambers. These anti-friction rollers bear upon the cylindrical parts of the axle *o*, of each wheel, and support the weight of the coach; *p*, is a bearing firmly secured in the axle-box to the plate *l*, for the end of the axle *o* to run in, the axle being confined in its proper situation by a collar and screw-nut on its end; *e*, is the vertical pin or bolt before mentioned, upon which the axle-bar turns when the

1196



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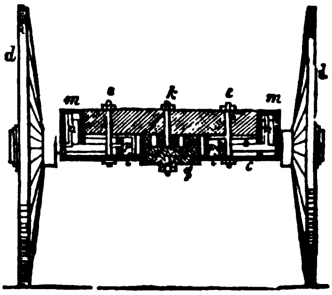
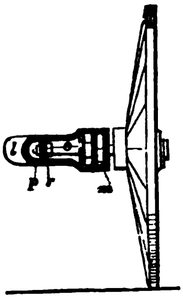
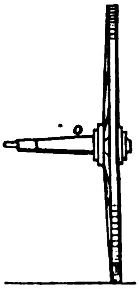


1200



wheels are locking, which bolt is enlarged within the box, and has an eye for the axle to pass through, being firmly secured to the plate *l*, and also to the sides of the box. *Fig.* 1200, is a plan or horizontal view of an axle and its box, belonging to one of the fore wheels; a piece *q*, is fixed to the under side of the main axletree, which supports the ends of the plates *l*, and thereby relieves the pins *e*, *e*, of the strain they would otherwise have to withstand. The axles of the hind wheels are mounted upon similar plates *l*, *l*, with bearings and chambers with anti-friction rollers; but as these are not required to lock, the plates *l*, *l*, are fixed on to the under side of the hind axletree by screw-nuts; there are small openings or doors, which can be removed for the purpose of unscrewing the nuts and collars of the bearings *p*, when the wheel is required to be taken off the carriage, when the axle can be withdrawn from the boxes. If it should be thought necessary, other chambers with friction rollers may be placed on the under side of the plate *l*, to bear up the end of the axles, and relieve the bearing *p*. In order to stop or impede the progress of a carriage in passing down hills, there is a grooved friction or brake wheel *t*, fixed, by clamps or otherwise, on to the spokes of one of the hind wheels; *u*, is a brake-band or spring, of metal, encircling the friction wheel, one end of which band is fixed into the standard *v*, upon the hind axletree, and the other end connected by a joint to the shorter end of the lever *w*, which has its fulcrum in the standard *v*; this lever extends up to the hind seat of the coach, as shown in *fig.* 1198, and is intended to be under the command of the guard or passengers of the coach, and when descending a hill, or on occasion of the horses running away, the longer end of the lever is to be depressed, which will raise the shorter end, and, consequently, bring the band or spring *u*, in contact with the surface of the friction wheel, and thereby retard its revolution, and prevent the coach travelling too fast; or, instead of attaching the friction brake to the hind wheel, as represented in *fig.* 1198, it may be adapted to the fore wheels, and the end of the lever brought up to the side of the foot-board, or under it, and within command of the coachman, the standard which carries the fulcrum being made to move upon a pivot, to accommodate the locking of the wheels. It will be observed, that by these improved constructions of the carriage, and mode of locking, the patentee is enabled to use much larger fore wheels than in common, and that the splinter-bars will always be in the position of right angles with the track or way of the horses in drawing the carriage, by which they are much relieved, and always pull in a direct and equal manner.

1199



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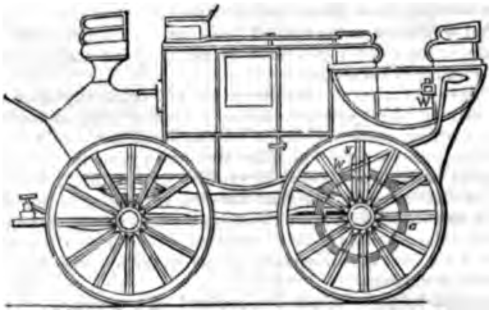

A manifest defect in all four-wheeled carriages, involving vast superfluous friction, is the small size of the front wheels; a defect which has existed ever since Walter Rippon made "the first hollow *turning* coach with pillars and arches for her majesty Queen Mary, being then her servant," until the railroad era, when our engineers remedied the defect by equalizing the wheels, at the expense of another defect—sacrificing the power of turning, and thus producing great lateral friction; whence a train of evil consequences result:—necessarily increased strength, and consequently increased weight of the carriages; increased power and weight of the engine to draw them, and overcome the friction; and, of course, increased strength of rails, and greater solidity of railway.

These defects are at last remedied by an invention patented by Mr. William Adams, author of a work entitled "English Pleasure Carriages." Instead of placing the perch-bolt, or turning centre, as is commonly done, over the front axle, he places it at a convenient distance *between* the front and hind axles; so that when turning the carriage the front wheels, instead of turning *beneath* the body, as is common, turn outside of it, and the driver's seat turns with them; thus giving him a perfect command over his horses in all positions, instead of the usual dangerous plan, which renders a driver liable to be pulled off his box by a restiff horse, when in the act of turning. A carriage constructed on Mr. Adams's plan may also be driven round a corner at full speed, without any risk of overturning, as the weight is equally poised on the axles in all positions. It is well known that the oversetting of stage coaches usually takes place when turning a corner, the momentum urging the vehicle in a right line, while the horses are pulling at an angle. By the new arrangement the front wheels may be made equal to the hind ones, or of any desirable height, and at the same time the body may be kept as low as may be thought convenient, even almost close to the ground, if desired. Thus two important objects, hitherto deemed incompatible, are combined—high wheels and a low centre of gravity. These carriages are therefore essentially safety carriages, while the friction is reduced to a minimum. The principle, in its various modifications, is applicable to every variety of carriage, both those of the simply useful kind, and those where beauty of form and color are prime requisites.

Another most important part of Mr. Adams's invention, is his new mode of spring suspension; applying the principle of the bow and string, for the first time, to obviate the effects of concussion in wheel carriages. All the springs hitherto in use for wheel carriages, have been friction springs, composed of long sliding surfaces, uncertain in their action, and liable to quick destruction by rust. But Mr. Adams's springs are essentially elastic, being formed of single plates abutting endways, so that all friction is removed, and they can be hermetically sealed within paint to prevent their corrosion. He has various modes of applying the bow, either single or double, above or below the axle; but one most important feature is, that the axle being attached to the flexible cords or braces, the concussion which affects the wheels, either laterally, vertically, or in the line of progress, is perfectly intercepted, without the unpleasant oscillation experienced in carriages where the same purpose is accomplished by the use of the curved or C spring. Mr. Adams's brace being, at the same time, a non-conductor of sound, the rattling of the wheels does not annoy the rider as in ordinary carriages. His springs are equally applicable to vehicles with two and four wheels.

The advantages of these carriages may be thus summed up:—A great diminution of the total weight; a diminution of resistance in draught equal to about one third; increase of safety to the riders; increased durability of the vehicle; absence of noise and vibration; absence of oscillation.

To these qualities, so desirable to all, and especially those of delicate nervous temperament, may be added—greater economy, both in the first cost and maintenance.

The *whirling* public so blindly follows fashionable caprice in the choice of a carriage, as to have hitherto paid too little attention to this fundamental improvement; but many intelligent individuals have fully verified its practical reality. Having inspected various forms of two-wheeled and four-wheeled carriages, in the patentee's premises in Drury Lane, I feel justified in recommending them as being constructed on the soundest mechanical principles; and have no doubt, that if reason be allowed to decide upon their merits, they will ere long be universally preferred by all who seek for easy-moving, safe, and comfortable vehicles.

WHETSLATE, is a massive mineral of a greenish-gray color; feebly glimmering; fracture, slaty or splintery; fragments tabular; translucent on the edges; feels rather greasy; and has a spec. grav. of 2·722. It occurs in beds, in primitive and transition slates. Very fine varieties of whetslate are brought from Turkey, called *hone-stones*, which are in much esteem for sharpening steel instruments.

WHEY (*Petit lait*, Fr.; *Molken*, Germ.), is the greenish-gray liquor which exudes from the curd of milk. Scheele states, that when a pound of milk is mixed with a spoonful of proof spirit, and allowed to become sour, the whey filtered off, at the end of a month or a little more, is a good vinegar, devoid of lactic acid.

WHISKEY, is dilute alcohol, distilled from the fermented worts of malt or grains.

WHITE LEAD, *Carbonate of lead, or Ceruse.* (*Blanc de plomb*, Fr.; *Bleiweiss*, Germ.) This preparation is the only one in general use for painting wood and the plaster walls of apartments white. It mixes well with oil, without having its bright color impaired, spreads easily under the brush, and gives a uniform coat to wood, stone, metal, &c. It is employed either alone, or with other pigments, to serve as their basis, and to give them body. This article has been long manufactured with much success at Klagenfurth in Carinthia, and its mode of preparation has been lately described with precision by Marcel de Serres. The great white-lead establishments at Krems, whence, though incorrectly, the terms *white of Kremnitz* became current on the continent, have been abandoned.

1. The lead comes from Bleyberg; it is very pure, and particularly free from contamination with iron, a point essential to the beauty of its factitious carbonate. It is melted

in ordinary pots of cast iron, and cast into sheets of varying thickness, according to the pleasure of the manufacturer. These sheets are made by pouring the melted lead upon an iron plate placed over the boiler; and whenever the surface of the metal begins to consolidate, the plate is slightly sloped to one side, so as to run off the still liquid metal, and leave a lead sheet of the desired thinness. It is then lifted off like a sheet of paper; and as the iron plate is cooled in water, several hundred weights of lead can be readily cast in a day. In certain white-lead works these sheets are one twenty-fourth of an inch thick; in others, half that quantity; in some, one of these sheets takes up the whole width of the conversion-box; in others, four sheets are employed. It is of consequence not to smooth down the faces of the leaden sheets; because a rough surface presents more points of contact, and is more readily attacked by acid vapors, than a polished one.

2. These plates are now placed so as to expose an extensive surface to the acid fumes, by folding each other over a square slip of wood. Being suspended by their middle, like a sheet of paper, they are arranged in wooden boxes, from 4½ to 5 feet long, 12 to 14 inches broad, and from 9 to 11 inches deep. The boxes are very substantially constructed; their joints being mortised; and whatever nails are used being carefully covered. Their bottom is made tight with a coat of pitch about an inch thick. The mouths of the boxes are luted over with paper, in the works where fermenting horse-dung is employed as the means of procuring heat, to prevent the sulphureted and phosphureted hydrogen from injuring the purity of the white lead. In Carinthia it was formerly the practice, as also in Holland, to form the lead sheets into spiral rolls, and to place them so coiled up in the chests; but this plan is not to be recommended, because these rolls present obviously less surface to the action of the vapors, are apt to fall down into the liquid at the bottom, and thus to impair the whiteness of the lead. The lower edges of the sheets are suspended about two inches and a half from the bottom of the box; and they must not touch either one another or its sides, for fear of obstructing the vapors in the first case, or of injuring the color in the second. Before introducing the lead, a peculiar acid liquor is put into the box, which differs in different works. In some, the proportions are four quarts of vinegar, with four quarts of wine-lees; and in others, a mixture is made of twenty pounds of wine-lees, with eight and a half pounds of vinegar, and a pound of carbonate of potash. It is evident that in the manufactories where no carbonate of potash is employed in the mixture, and no dung for heating the boxes, it is not necessary to lute them.

3. The mixture being poured into the boxes, and the sheets of lead suspended within them, they are carried into a stove-room, to receive the requisite heat for raising round the lead the corrosive vapors, and thus converting it into carbonate. This apartment is heated generally by stoves, is about 9 feet high, 30 feet long, and 24 feet wide, or of such a size as to receive about 90 boxes. It has only one door.

The heat should never be raised above 86° Fahr.; and it is usually kept up for fifteen days, in which time the operation is, for the most part, completed. If the heat be too high, and the vapors too copious, the carbonic acid escapes in a great measure, and the metallic lead, less acted upon, affords a much smaller product.

When the process is well managed, as much carbonate of lead is obtained, as there was employed of metal; or, for 300 pounds of lead, 300 of ceruse are procured, besides a certain quantity of metal after the crusts are removed, which is returned to the melting-pot. The mixture introduced into the boxes serves only once; and if carbonate of potash has been used, the residuary matter is sold to the hatters.

4. When the preceding operation is supposed to be complete, the sheets, being removed from the boxes, are found to have grown a quarter of an inch thick, though previously not above a twelfth of that thickness. A few pretty large crystals of acetate of lead are sometimes observed on their edges. The plates are now shaken smartly, to cause the crust of carbonate of lead formed on their surfaces to fall off. This carbonate is put into large cisterns, and washed very clean. The cistern is of wood, most commonly of a square shape, and divided into from seven to nine compartments. These are of equal capacity, but unequal height, so that the liquid may be made to overflow from one to the other. Thereby, if the first chest is too full, it decants its excess into the second, and so on in succession. See RINSING MACHINE.

The water poured into the first chest passes successively into the others, a slight agitation being meanwhile kept up, and there deposites the white lead diffused in it proportionally, so that the deposite of the last compartment is the finest and lightest. After this washing, the white lead receives another, in large vats, where it is always kept under water. It is lastly lifted out in the state of a liquid paste, with wooden spoons, and laid on drying-tables to prepare it for the market.

The white lead of the last compartment is of the first quality, and is called on the continent silver white. It is employed in fine painting.

When white lead is mixed in equal quantities with ground sulphate of barytes, it is known in France and Germany by the name of Venice white. Another quality, adulterated with double its weight of sulphate of barytes, is styled Hamburgh white; and a fourth, having three parts of sulphate to one of white lead, gets the name of Dutch white. When the sulphate of barytes is very white, like that of the Tyrol, these mixtures are reckoned preferable for certain kinds of painting, as the barytes communicates opacity to the color, and protects the lead from being speedily darkened by sulphureous smoke or vapors.

The high reputation of the white lead of Krems was by no means due to the barytes, for the first and whitest quality was mere carbonate of lead. The freedom from silver of the lead of Villach, a very rare circumstance, is one cause of the superiority of its carbonate; as well as the skilful and laborious manner in which it is washed, and separated from any adhering particle of metal or sulphuret.

In England, lead is converted into carbonate in the following way:—The metal is cast into the form of a net-work grating, in moulds about fifteen inches long, and four or five broad. Several rows of these are placed over cylindrical glazed earthen pots, about four or five inches in diameter, containing some treacle-vinegar, which are then covered with straw; above these pots another range is piled, and so in succession, to a convenient height. The whole are imbedded in spent bark from the tan-pit, brought into a fermenting state by being mixed with some bark used in a previous process. The pots are left undisturbed under the influence of a fermenting temperature for eight or nine weeks. In the course of this time the lead gratings become, generally speaking, converted throughout into a solid carbonate, which when removed is levigated in a proper mill, and elutriated with abundance of pure water. The plan of inserting coils of sheet lead into earthenware pipkins containing vinegar, and imbedding the pile of pipkins in fermenting horse-dung and litter, is now little used; because the coil is not uniformly acted on by the acid vapors, and the sulphureted hydrogen evolved from the dung is apt to darken the white lead.

In the above processes, the conversion of lead into carbonate seems to be effected by keeping the metal immersed in a warm, humid atmosphere, loaded with carbonic and acetic acids; and hence a pure vinegar does not answer well; but one which is susceptible, by its spontaneous decomposition in these circumstances, of yielding carbonic acid. Such are tartar, wine-lees, molasses, &c.

Another process has lately been practised to a considerable extent in France, though it does not afford a white lead equal in body and opacity to the products of the preceding operations. M. Thenard first established the principle, and MM. Brechoz and Leseur contrived the arrangements of this new method, which was subsequently executed on a great scale by MM. Roard and Brechoz.

A subacetate of lead is formed by digesting a cold solution of uncrystallized acetate, over litharge, with frequent agitation. It is said that 65 pounds of purified pyroligneous acid, of specific gravity 1·056, require, for making a neutral acetate, 58 pounds of litharge; and hence, to form the subacetate, three times that quantity of base, or 174 pounds, must be used. The compound is diluted with water as soon as it is formed, and being decanted off quite limpid, is exposed to a current of carbonic acid gas, which, uniting with the two extra proportions of oxyde of lead in the subacetate, precipitates them in the form of a white carbonate, while the liquid becomes a faintly acidulous acetate. The carbonic acid may be extricated from chalk, or other compounds, or generated by combustion of charcoal, as at Clichy; but in the latter case, it must be transmitted through a solution of acetate of lead before being admitted into the subacetate, to deprive it of any particles of sulphureted hydrogen. When the precipitation of the carbonate of lead is completed, and well settled down, the supernatant acetate is decanted off, and made to act on another dose of litharge. The deposite being first rinsed with a little water, this washing is added to the acetate; after which the white lead is thoroughly elutriated. This repetition of the process may be indefinitely made; but there is always a small loss of acetate, which must be repaired, either directly or by adding some vinegar.

In order to obtain the finest white lead by the process with earthen pots containing vinegar buried in fermenting tan, and covered by a grating of lead, the metal should be so thin as to be entirely convertible into carbonate; for whenever any of it remains, it is apt to give a gray tint to the product; if the temperature of the fermenting mass is less than 90° Fahr., some particles of the metal will resist the action of the vinegar, and degrade the color; and if it exceeds 122°, the white verges into yellow, in consequence of some carbonaceous compound being developed from the principles of the acetic acid. The dung and tan have been generally supposed to act in this process by supplying carbonic acid, the result of their fermentation; but it is now said that this explanation is inexact, because the best white lead can be obtained by the entire exclusion of air from the pots in which the carbonization of the metal is carried on. We are thence led to conclude that the lead is oxydized at the expense of the oxygen of the vinegar, and carbonated by the agency of its oxygen and carbon; the hydrogen of the acid being left to associate itself with the remaining oxygen and carbon, so as to constitute an ethereous compound: thus, supposing the three atoms of oxygen to form, with one of lead and one of carbon, an atom of carbonate, then the remaining three atoms of carbon and three of hydrogen would compose olefiant gas.

It is customary on the continent to mould the white lead into conical loaves, before sending them into the market. This is done by stuffing well-drained white lead into unglazed earthen pots, of the requisite size and shape, and drying it to a solid mass, by exposing these pots in stove-rooms. The moulds being now inverted on tables, discharge their contents, which then receive a final desiccation; and are afterwards put up in pale-blue paper, to set off the white color by contrast. Nothing in all the white-lead process is so injurious as this pot operation; a useless step, fortunately unknown in Great Britain. Neither greasing the skin, nor wearing thick gloves, can protect the operators from the diseases induced by the poisonous action of the white lead; and hence they must be soon sent off to some other department of the work.

It has been supposed that the differences observed between the ceruse of Clichy and the common kinds, depend on the greater compactness of the particles of the latter, produced by their slower aggregation; as also, according to M. Robiquet, on the former containing considerably less carbonic acid. See *infrà*.

Mr. Ham proposed, in a patent dated June, 1826, to produce white lead with the aid of the following apparatus. *a*, *a* (*fig.* 1201) are the side-walls of a stove-room, constructed of bricks; *b*, is the floor of bricks laid in Roman cement; *c*, *c*, are the side-plates, between which and the walls, a quantity of refuse tanner's bark, or other suitable vegetable matter, is to be introduced. The same material is to be put also into the lower part at *d* (upon a false bottom of grating ?) The tan should rise to a considerable height, and have a series of strips of sheet lead *e*, *e*, *e*, placed upon it, which are kept apart by blocks or some other convenient means, with a space open at one end of the plates, for the passage of the vapors; but above the upper plates, boards are placed, and covered with tan, to confine them there. In the lower part of the chamber, coils of steam-pipe *f*, *f*, are laid in different directions to distribute heat; *g*, is a funnel-pipe, to conduct vinegar into the lower part of the vessel; and *h*, is a cock to draw it off, when the operation is suspended. The acid vapors raised by the heat, pass up through the spent bark, and on coming into contact with the sheets of lead, corrode them. The quantity of acid liquor should not be in excess; a point to be ascertained by means of the small tube *i*, at top, which is intended for testing it by the tongue. *k*, is a tube for inserting a thermometer, to watch the temperature, which should not exceed 170° Fahr. I am not aware of what success has attended this patented arrangement. The heat prescribed is far too great.

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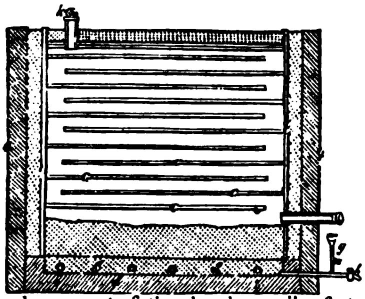


A magnificent factory has been recently erected at West Bromwich, near Birmingham, to work a patent lately granted to Messrs. Gossage and Benson, for making white lead by mixing a small quantity of acetate of lead in solution with slightly damped litharge, contained in a long stone trough, and passing over the surface of the trough currents of hot carbonic acid, while its contents are powerfully stirred up by a travelling-wheel mechanism. The product is afterwards ground and elutriated, as usual. The carbonic acid gas is produced from the combustion of coke. I am told that 40 tons of excellent white lead are made weekly by these chemico-mechanical operations.

Messrs. Button and Dyer obtained a patent about a year and a half ago, for making white lead by transmitting a current of purified carbonic acid gas, from the combustion of coke, through a mixture of litharge and nitrate of lead, diffused and dissolved in water, which is kept in constant agitation and ebullition by steam introduced through a perforated coil of pipes at the bottom of the tub. The carbonate of lead is formed here upon the principle of Thenard's old process with the subacetate; for the nitrate of lead forms with the litharge a subnitrate, which is forthwith transformed into carbonate and neutral nitrate, by the agency of the carbonic acid gas. I have discovered that all sorts of white lead produced by precipitation from a liquid, are in a semi-crystalline condition; they appear, therefore, semi-transparent, when viewed in the microscope; and do not cover so well as white lead made by the process of vinegar and tan, in which the lead has remained always solid during its transition from the blue to the white state; and hence consists of opaque particles.

A patent was obtained, in December, 1833, by John Baptiste Constantine Torassa, and others, for making white lead by agitating the granulated metal, or shot, in trays or barrels, along with water, and exposing the mixture of lead-dust and water to the air, to be oxydized and carbonated. It is said that upwards of 100,000*l*. have been expended at Chelsea, by a joint stock company, in a factory constructed for executing the preceding most operose and defective process; which has been, many years ago, tried without success in Germany. I am convinced that the whole of these recent projects for preparing white lead, are inferior in economy, and quality of produce, to the old Dutch process, which may be so arranged as to convert sheets of blue lead thoroughly into the best white lead, within the space of 12 days, at less expense of labor than by any other plan.

White lead, as obtained by precipitation from the acetate, subacetate, and subnitrate, is a true carbonate of the metal, consisting of one prime equivalent of lead 104, one of oxygen 8, and one of carbonic acid 22; whose sum is 134, the atomic weight of the compound; or, of lead, 77·6; oxygen, 6; carbonic acid, 16·4; in 100 parts. It has been supposed, by some authors, that the denser and better-covering white lead of Krems and Holland is a kind of subcarbonate, containing only 9 per cent. of carbonic acid; but this view of the subject does not accord with my researches.

Wick (*Mèche*, Fr.; *Docht*, Germ.), is the spongy cord, usually made of soft spun cotton threads, which by capillary action draws up the oil in lamps, or the melted tallow or wax in candles, in small successive portions, to be burned. In common wax and tallow candles, the wick is formed of parallel threads; in the stearine candles, the wick is plaited upon the braiding machine, moistened with a very dilute sulphuric acid, and dried, whereby, as it burns, it falls to one side and consumes without requiring to be snuffed; in the patent candles of Mr. Palmer, one tenth of the wick is first imbued with subnitrate of bismuth ground up with oil, the whole is then bound round in the manner called *gimping;* and of this wick, twice the length of the intended candle is twisted double round a rod, like the *caduceus of Mercury.* This rod with its coil being inserted in the axis of the candle mould, is to be enclosed by pouring in the melted tallow; and when the tallow is set, the rod is to be drawn out at top, leaving the wick in the candle. As this candle is burned, the ends of the double wick stand out sideways beyond the flame; and the bismuth attached to the cotton being acted upon by the oxygen of the atmosphere, causes the wick to be completely consumed, and, therefore, saves the trouble of snuffing it.

WINCING-MACHINE, is the English name of the dyer's reel, which he suspends horizontally, by the ends of its iron axis in bearings, over the edge of his vat, so that the line of the axis, being placed over the middle partition in the copper, will permit the piece of cloth which is wound upon the reel to descend alternately into either compartment of the bath, according as it is turned by hand to the right or the left. For an excellent self-acting or mechanical wince, see DYEING.

WINE, is the fermented juice of the grape. In the more southern states of Europe, the grapes, being more saccharine, afford a more abundant production of alcohol, and stronger wines, as exemplified in the best port, sherry, and madeira. The influence of solar heat upon the vines may, however, be mitigated by growing them to moderate heights on level ground, and by training them in festoons under the shelter of trees. In the more temperate climates, such as the district of Burgundy, the finer flavored wines are produced; and there the vines are usually grown upon hilly slopes fronting the south, with more or less of an easterly or westerly direction, as on the Côte d'Or, at a distance from marshes, forests, and rivers, whose vapors might deteriorate the air. The plains of this district, even when possessing a similar or analogous soil, do not produce wines of so agreeable a flavor. The influence of temperature becomes very manifest in countries further north, where, in consequence of a few degrees of thermometric depression, the production of generous agreeable wine becomes impossible.

The land most favorable to the vine is light, easily permeable to water, but somewhat retentive by its composition; with a sandy subsoil, to allow the excess of moisture to drain readily off. Calcareous soils produce the highly esteemed wines of the Côte d'Or; a granite debris forms the foundations of the lands where the Hermitage wines are grown; silicious soil interspersed with flints furnishes the celebrated wines of Château-Neuf, Ferté, and La Gaude; schistose districts afford also good wine, as that called *la Malgue.* Thus we see that lands differing in chemical composition, but possessed of the proper physical qualities, may produce most agreeable wines; and so also may lands of like chemical and physical constitution produce various kinds of wine, according to their varied exposure. As a striking example of these effects, we may adduce the slopes of the hills which grow the wines of Montrachet. The insulated part towards the top furnishes the wine called *Chevalier Montrachet*, which is less esteemed, and sells at a much lower price, than the delicious wine grown on the middle height, called *true Montrachet.* Beneath this district, and in the surrounding plains, the vines afford a far inferior article, called *bastard Montrachet.* The opposite side of the hills produces very indifferent wine. Similar differences, in a greater or less degree, are observable relatively to the districts which grow the Pomard, Volnay, Beaune, Nuits, Vougeot, Chambertin, Romanée, &c. Everywhere it is found, that the reverse side of the hill, the summit, and the plain, although generally consisting of like soil, afford inferior wine to the middle southern slopes.

Amelioration of the soil.—When the vine lands are too light or too dense, they may be modified, within certain limits, by introducing into them either argillaceous or siliceous matter. Marl is excellent for almost all grounds which are not previously too calcareous, being alike useful to open dense soils, and to render porous ones more retentive.

Manure.—For the vine, as well as all cultivated plants, a manure supplying azotized or animal nutriment may be used with great advantage, provided care be taken to ripen it by previous fermentation, so that it may not, by absorption in too crude a state, impart any disagreeable odor to the grape; as sometimes happens to the vines grown in the vicinity of great towns, like Paris, and near Argenteuil. There is a compost used in France, called *animalized black*, of which from one fifth to one half of a litre (old English quart) serves sufficiently to fertilize the root of one vine, when applied every year, or two years. An excess of manure, in rainy seasons especially, has the effect of rendering the grapes large and insipid.

The ground is tilled at the same time as the manure is applied, towards the month of March; the plants are then dressed, and the props are inserted. The weakness of the plants renders this practice useful; but in some southern districts, the stem of the vine, when supported at a proper height, acquires after a while sufficient size and strength to stand alone. The ends of the props or poles are either dipped in tar, or charred, to prevent their rotting. The bottom of the stem must be covered over with soil, after the spring rains have washed it down. The principal husbandry of the vineyard consists in digging or ploughing to destroy the weeds, and to expose the soil to the influence of the air, during the months of May, June, and occasionally in August.

The vintage, in the temperate provinces, generally takes place about the end of September; and it is always deteriorated whenever the fruit is not ripe enough before the 15th or 20th of October; for, in this case, not only is the must more acid, and less saccharine, but the atmospherical temperature is apt to fall so low during the nights, as to obstruct more or less its fermentation into wine. The grapes should be plucked in dry weather, at the interval of a few days after they are ripe; being usually gathered in baskets, and transported to the vats in dorsels, sufficiently tight to prevent the juice from running out. Whenever a layer about 14 or 15 inches thick has been spread on the bottom of the vat, the treading operation begins, which is usually repeated after macerating the grapes for some time, when an incipient fermentation has softened the texture of the skin and the interior cells. When the whole bruised grapes are collected in the vat, the juice, by means of a slight fermentation, reacts, through the acidity thus generated, upon the coloring matter of the husks, and also upon the tannin contained in the stones and the fruit-stalks. The process of fermentation is suffered to proceed without any other precaution, except forcing down from time to time the pellicles and pedicles floated up by the carbonic acid to the top; but it would be less apt to become acetous, were the mouths of the vats covered. With this view, M. Sebille Auger introduced with success his elastic bung in the manufacture of wine in the department of the Maine-et-Loire.

With whatever kind of apparatus the fermentation may have been regulated, as soon as it ceases to be tumultuous, and the wine is not sensibly saccharine or muddy, it must be racked off from the lees, by means of a spigot, and run into the ripening tuns. The marc being then gently squeezed in a press, affords a tolerably clear wine, which is distributed among the tuns in equal proportions; but the liquor obtained by stronger pressure is reserved for the casks of inferior wine.

In the south of France the fermentation sometimes proceeds too slowly, on account of the must being too saccharine; an accident which is best counteracted by maintaining a temperature of about 65° or 68° F., in the tun-room. When the must, on the other hand, is too thin, and deficient in sugar, it must be partially concentrated by rapid boiling, before the whole can be made to ferment into a good wine. By boiling up a part of the must for this purpose, the excess of ferment is at the same time destroyed. Should this concentration be inconvenient, a certain proportion of sugar must be introduced, immediately after racking it off.

The specific gravity of must varies with the richness and ripeness of the grapes which afford it; being in some cases so low as 1·0627, and in others so high as 1·1283. This happens particularly in the south of France. In the district of the Necker in Germany, the specific gravity varies from 1·050 to 1·090; in Heidelberg, from 1·039, to 1·091; but it varies much in different years.

After the fermentation is complete, the vinous part consists of water, alcohol, a coloring-matter, a peculiar aromatic principle, a little undecomposed sugar, bitartrate and malate of potash, tartrate of lime, muriate of soda, and tannin; the latter substances being in small proportions.

It is known that a few green grapes are capable of spoiling a whole cask of wine, and therefore they are always allowed to become completely ripe, and even sometimes to undergo a species of slight fermentation, before being plucked, which completes the development of the saccharine principle. At other times the grapes are gathered whenever they are ripe, but are left for a few days on wicker-floors, to sweeten, before being pressed.

In general the whole vintage of the day is pressed in the evening, and the resulting must is received in separate vats. At the end usually of 6 or 8 hours, if the temperature be above 50° F., and if the grapes have not been too cold when plucked, a froth or scum is formed at the surface, which rapidly increases in thickness. After it acquires such a consistence as to crack in several places, it is taken off with a skimmer, and drained; and the thin liquor is returned to the vat. A few hours afterwards another coat of froth is formed, which is removed in like manner, and sometimes a third may be produced. The regular vinous fermentation now begins, characterized by air-bubbles rising up the sides of the staves, with a peculiar whizzing as they break at the surface. At this period all the remaining froth should be quickly skimmed off, and the clear subjacent must be transferred into barrels, where it is left to ripen by a regular fermentation.

The white wines, which might be disposed to become stringy, from a deficient supply of tannin, may be preserved from this malady by a due addition of the footstalks of ripe grapes. The tannin, while it tends to preserve the wines, renders them also more easy to clarify, by the addition of white of egg, or ising-glass.

The white wines should be racked off as soon as the first frosts have made them clear, and at the latest by the end of the February moon. By thus separating the wine from the lees, we avoid, or render of little consequence, the fermentation which takes place on the return of spring, and which, if too brisk, would destroy all its sweetness, by decomposing the remaining portion of sugar.

The characteristic odor possessed by all wines, in a greater or less degree, is produced by a peculiar substance, which possesses the characters of an essential oil. As it is not volatile, it cannot be confounded with the aroma of wine. When large quantities of wine are distilled, an oily substance is obtained towards the end of the operation. This may also be procured from the wine lees which are deposited in the casks after the fermentation has commenced. It forms one forty thousandth part of the wine; and consists of a peculiar new acid, and ether, each of which has been called the *œnanthic*. The acid is analogous to the fatty acids, and the ether is liquid, but insoluble in water. The acid is perfectly white when pure, of the consistence of butter at 60°, melts with a moderate heat, reddens litmus, and dissolves in caustic and carbonated alkalis, as well as in alcohol and ether. Œnanthic ether is colorless, has an extremely strong smell of wine, which is almost intoxicating when inhaled, and a powerful disagreeable taste. *Liebig and Pelouze.*

Sparkling wines.—In the manufacture of these, black grapes of the first quality are usually employed, especially those gathered upon the vine called by the French *noirien*, cultivated on the best exposures. As it is important, however, to prevent the coloring-matter of the skin from entering into the wine, the juice should be squeezed as gently and rapidly as possible. The liquor obtained by a second and third pressing is reserved for inferior wines, on account of the reddish tint which it acquires. The marc is then mixed with the grapes of the red-wine vats.

The above nearly colorless must is immediately poured into tuns or casks, till about three fourths of their capacity are filled, when fermentation soon begins. This is allowed to continue under the control of the elastic bung, above mentioned, for about 15 days, and then three fourths of the casks are filled up with wine from the rest. The casks are now closed by a bung secured with a piece of hoop iron nailed to two contiguous staves. The casks should be made of new wood, but not of oak—though old white wine casks are occasionally used.

In the month of January the clear wine is racked off, and is fined by a small quantity of ising-glass dissolved in old wine of the same kind. Forty days afterwards a second fining is required. Sometimes a third may be useful, if the lees be considerable. In the month of May the clear wine is drawn off into bottles, taking care to add to each of them a small measure of what is called *liquor*, which is merely about 3 per cent. of a sirup made by dissolving sugar-candy in white wine. The bottles being filled, and their corks secured by packthread and wire, they are laid on their sides, in this month, with their mouths sloping downwards at an angle of about twenty degrees, in order that any sediment may fall into the neck. At the end of 8 or 10 days, the inclination of the bottles is increased, when they are slightly tapped, and placed in a vertical position; so that after the lees are all collected in the neck, the cork is partially removed for an instant, to allow the sediment to be expelled by the pressure of the gas. If the wine be still muddy in the bottles, along with a new dose of *liquor*, a small quantity of fining should be added to each, and the bottles should be placed again in the inverted position. At the end of 2 or 3 months, the sediment collected over the cork is dexterously discharged; and if the wine be still deficient in transparency, the same process of fining must be repeated.

Sparkling wine (*vin mousseux*), prepared as above described, is fit for drinking usually at the end of from 18 to 30 months, according to the state of the seasons. It is in Champagne that the lightest, most transparent, and most highly flavored wines have been hitherto made. The breakage of the bottles in these sparkling wines amounts frequently to thirty per cent., a circumstance which adds greatly to their cost of production.

Weak wines of bad growths ought to be consumed within 12 or 15 months after being manufactured; and should be kept meanwhile in cool cellars. White wines of middling strength ought to be kept in casks constantly full, and carefully excluded from contact of air, and the racking off should be done as quickly as possible. As the most of them are injured by too much fermentation, this process should be so regulated as always to leave a little sugar undecomposed. It is useful to counteract the absorption of oxygen, and the consequent tendency to acidity, by burning a sulphur match in the casks into which they are about to be run. This is done by hooking the match to a bent wire, kindling and suspending it within the cask through the bung-hole. Immediately on withdrawing the match, the cask should be corked, if the wine be not ready for transfer. If the burning sulphur be extinguished on plunging it into the cask, it is a proof of the cask being unsound, and unfit for receiving the wine; in which case it should be well cleansed, first with lime-water, then with very dilute sulphuric acid, and lastly with boiling water.

Wine-cellars ought to be dry at bottom, floored with flags, have windows opening to the north, be so much sunk below the level of the adjoining ground as to possess a nearly uniform temperature in summer and winter; and be at such a distance from a frequented highway or street as not to suffer vibration from the motion of carriages.

Wines should be racked off in cool weather; the end of February being the fittest time for light wines. Strong wines are not racked off till they have stood a year or eighteen months upon the lees, to promote their slow or insensible fermentation. A syphon well managed serves better than a faucet to draw off wine clear from the sediment. White wines, before being bottled, should be fined with ising-glass; red wines are usually fined with whites of eggs beat up into a froth, and mixed with two or three times their bulk of water. But some strong wines, which are a little harsh from excess of tannin, are fined with a little sheep or bullock's blood. Occasionally a small quantity of sweet glue is used for this purpose.

The following maladies of wines, are certain accidental deteriorations, to which remedies should be speedily applied.

La-pousse (pushing out of the cask), is the name given to a violent fermentative movement, which occasionally supervenes after the wine has been run off into the casks. If these have been tightly closed, the interior pressure may increase to such a degree as to burst the hoops, or cause the seams of the staves or ends to open. The elastic bungs already described will prevent the bursting of the casks; but something must be done to repress the fermentation, lest it should destroy the whole of the sugar, and make the wine unpalatably harsh. One remedy is, to transfer the wine into a cask previously fumigated with burning sulphur; another is, to add to it about one thousandth part of sulphite of lime; and a third, and perhaps the safest, is to introduce half a pound of mustard-seed into each barrel. At any rate, the wines should be fined whenever the movements are allayed, to remove the floating ferment which has been the cause of the mischief.

Turning sour.—The production of too much acid in a wine, is a proof of its containing originally too little alcohol, of its being exposed too largely to the air, or to vibrations, or to too high a temperature in the cellar. The best thing to be done in this case is, to mix it with its bulk of a stronger wine in a less advanced state, to fine the mixture, to bottle it, and to consume it as soon as possible, for it will never prove a good keeping wine. This *distemper* in wines formerly gave rise to the very dangerous practice of adding litharge as a sweetener; whereby a quantity of acetate or sugar of lead was formed in the liquor, productive of the most deleterious consequences to those who drank of it. In France, the regulations of police, and the enlightened *surveillance* of the council of salubrity, have completely put down this gross abuse. The saturation of the acid by lime and other alkaline bases has generally a prejudicial effect, and injures more or less the vinous flavor and taste.

Ropiness or viscidity of wines.—The cause of this phenomenon, which renders wine unfit for drinking, was altogether unknown, till M. François, an apothecary of Nantes, demonstrated that it was owing to an azotized matter, analogous to *gliadine* (gluten); and in fact it is the white wines, especially those which contain the least tannin, which are subject to this malady. He also pointed out the proper remedy, in the addition of tannin under a rather agreeable form, namely, the bruised berries of the mountain-ash (*sorbier*), in a somewhat unripe state; of which one pound, well stirred in, is sufficient for a barrel. After agitation, the wine is to be left in repose for a day or two, and then racked off. The tannin by this time will have separated the azotized matter from the liquor, and removed the ropiness. The wine is to be fined and bottled off.

The taste of the cask, which sometimes happens to wine put into casks which had remained long empty, is best remedied by agitating the wine for some time with a spoonful of olive oil. An essential oil, the chief cause of the bad taste, combines with the fixed oil, and rises with it to the surface.

According to a statement in the *Dictionnaire Technologique*, the annual produce of a hectare of vineyard, upon the average of 113 years, in the district of Volnay, is 1779 litres, which fetch 0·877 francs each, or 200 francs the piece of 228 litres, amounting in all to 1672 francs. Deducting for expenses and taxes (*contributions*) 572 francs, there remain 1,100 francs of net proceeds; and as the value of the capital may be estimated at 23,000 francs, the profit turns out to be no more than 5 per cent. The net proceeds in the growths of Beaune, Nuits, &c., does not exceed 600 francs per hectare (2·4 acres), and therefore is equivalent to only 2½ per cent. upon the capital.

The quantity of alcohol contained in different wines, has been made the subject of elaborate experiments by Brande and Fontenelle; but as it must evidently vary with different seasons, the results can be received merely as approximative. The only apparatus required for this research, is a small still and refrigeratory, so well fitted up as to permit none of the spirituous vapors to be dissipated. The distilled liquor should be received in a glass tube, graduated into one hundred measures, of such capacity as to contain the whole of the alcohol which the given measure of wine employed is capable of yielding. In the successive experiments, the quantity of wine used, and of spirit distilled over, being the same in volume, the relative densities of the latter will show at once the relative strengths of the wines. A very neat small apparatus has been contrived for the purpose of analyzing wines in this manner, by M. Gay Lussac. It is constructed, and sold at a moderate price, by M. Collardeau, No. 56, Rue Faubourg St. Martin, Paris. The proportion given by Brande (Table I.), has been reduced to the standard of absolute alcohol by Fesser; and that by Fontenelle (Table II.), to the same standard by Schubarth; as in the following tables:—

TABLE I.

Name of the wine.	Sp. grav.	100 measures contain at 60° F.		Name of the wine.	Sp. grav.	100 measures contain at 60° F.	
		Alcohol of 0·825.	Absolute alcohol.			Alcohol of 0·825.	Absolute alcohol.
Port Wine,..........	0·97616	21·40	19·82	Frontignac,..........	0·98452	17·79	11·84
Port Wine,..........	0·97200	25·83	23·92	Cote-Roti,..........	0·98495	12·27	11·36
Mean,..........	0·97460	23·49	21·75	Roussillon,..........	0·98005	17·24	15·96
Madeira,..........	0·97810	19·34	17·91	Cape Madeira,..........	0·97924	18·11	16·77
Madeira,..........	0·97333	21·42	22·61	Muscat..........	0·97913	18·25	17·00
Sherry,..........	0·97913	18·25	17·00	Constantia,..........	0·97770	19·75	18·29
Sherry..........	0·97700	19·83	18·37	Tinto,..........	0·98399	13·30	12·32
Bordeaux, Claret,..........	0·97410	12·91	11·95	Schiraz,..........	0·98176	15·52	14·35
Bordeaux, Claret,..........	0·97092	16·32	15·11	Syracuse,..........	0·98200	15·28	14·15
Calcavella,..........	0·97920	18·10	16·76	Nice,..........	0·98263	14·63	13·64
Lisbon,..........	0·97846	18·94	17·45	Tokay,..........	0·98760	9·88	9·15
Malaga,..........	0·98000	17·26	15·98	Raisin Wine,..........	0·97205	25·77	23·86
Bucellas,..........	0·97890	18·49	17·22	Drained grape Wine,..........	0·97925	18·11	16·77
Red Madeira,..........	0·97899	18·40	17·04	Lachrymæ Christi,..........	—	19·70	18·24
Malmsey,..........	0·98090	16·40	15·91	Currant Wine,..........	0·97696	20·55	19·03
Marsala,..........	0·98190	15·26	14·31	Gooseberry Wine,..........	0·98550	11·84	10·96
Marsala,..........	0·98000	17·26	15·98	Elder Wine,..........	0·98760	9·87	9·14
Champagne, [rose],..........	0·98608	11·30	10·46	Cider,..........			
Champagne, [white],..........	0·98150	12·80	11·84	Perry,..........			
Burgundy,..........	0·98300	14·53	13·34	Brown Stout,..........	0·99116	6·80	6·30
Burgundy,..........	0·98540	11·95	11·06	Ale,..........	0·98873	8·88	8·00
White Hermitage,..........	0·97990	17·43	16·14	Porter,..........	—	4·20	3·89
Red Hermitage,..........	0·98495	12·32	11·40	Rum,..........	0·93494	53·68	49·71
Hock,..........	0·98290	14·37	13·31	Hollands,..........	0·93855	51·60	47·77
Hock,..........	0·98873	8·88	8·00	Scotch Whiskey,..........	—	54·32	50·30
Vin de Grave,..........	0·98450	12·80	11·84	Irish Whiskey,..........	—	53·90	49·91

TABLE II.

Name of the Wine.	Absolute alcohol.	Name of the Wine.	Absolute alcohol.	Name of the Wine.	Absolute alcohol.
Roussillon (*Eastern Pyrenees.*)		Sijeau 8 yrs. old	8·635	Montpellier 5 yrs. old	7·413
		Narbonne 8 "	8·379	Lunel 8 "	7·564
Rive-saltes 18 yrs. old	9·156	Lezignan 10 "	8·173	Frontignan 5 "	7·098
Banyulls 18 "	9·223	Mirepeisset 10 "	8·589	Red Hermitage 4 "	5·838
Collyouvre 15 "	9·080	Carcasonne 8 "	7·190	White do. -	7·056
Salces 10 "	8·580			Burgundy 4 "	6·195
		Department of l'Herault.		Grave 3 "	5·838
Department of the Aude.				Champagne (sparkling)	5·880
		Nissau 9 "	7·896	Do. white do.	5·145
		Beziers 8 "	7·728	Do. rose -	4·956
Fitou and Leucaté 10 yrs. old	8·568	Montagnac 10 "	8·108	Bordeaux -	6·186
Lapalme 10 "	8·790	Mèze 10 "	7·812	Toulouse -	5·027

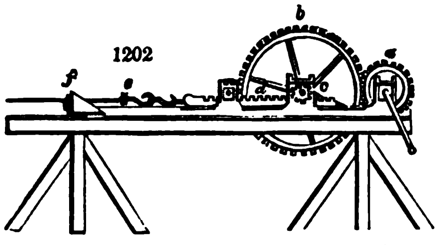
● WINE, FAMILY, may be made by the following recipe:—Take black, red, white currants, ripe cherries (black hearts are the best), and raspberries, of each an equal quantity. To 4 pounds of the mixed fruit, well bruised, put 1 gallon of clear soft water; steep three days and nights, in open vessels, frequently stirring up the magma; then strain through a hair sieve; press the residuary pulp to dryness, and add its juice to the former. In each gallon of the mixed liquors dissolve 3 pounds of good yellow muscovado sugar; let the solution stand other three days and nights, frequently skimming and stirring it up; then tun it into casks, which should remain full, and purging at the bunghole, about two weeks. Lastly, to every 9 gallons put 1 quart of good Cognac brandy (but not the drugged imitations made in London with grain whiskey), and bung down. If it does not soon become fine, a steeping of ising-glass may be stirred into the liquid, in the proportion of about half an ounce to 9 gallons. I have found that the addition of an ounce of cream of tartar to each gallon of the fermentable liquor, improves the quality of the wine, and makes it resemble more nearly the produce of the grape.

WINE-STONE is the deposite of crude tartar, called argal, which settles on the sides and bottoms of wine casks.

WIRE-DRAWING. (*Tréfilerie*, Fr.; *Draht-ziehen*, *Drahtzug*, Germ.) When an oblong lump of metal is forced through a series of progressively diminishing apertures in a steel plate, so as to assume in its cross section the form and dimensions of the last hole, and to be augmented in length at the expense of its thickness, it is said to be wire-drawn. The piece of steel called the *draw-plate* is pierced with a regular gradation of holes, from the largest to the smallest; and the machine for overcoming the lateral adhesion of the metallic particles to one another, is called the *draw-bench*. The pincers which lay hold of the extremity of the wire, to pull it through the successive holes, are adapted to bite it firmly, by having the inside of the jaws cut like a file. For drawing thick rods of gilt silver down into stout wire, the hydraulic press has been had recourse to with advantage.

Fig. 1202 represents a convenient form of the draw-bench, where the power is applied by a toothed wheel, pinion, and rack-work, moved by the hands of one or two men working at a winch; the motion being so regulated by a fly-wheel, that it does not proceed in fits and starts, and cause inequalities in the wire. The metal requires to be annealed, now and then, between successive drawings, otherwise it would become too hard and brittle for further extension. The reel upon which it is wound is sometimes mounted in a cistern of sour small beer, for the purpose of clearing off, or loosening at least, any crust of oxyde formed in the annealing, before the wire enters the draw-plate.

1202



When, for very accurate purposes of science or the arts, a considerable length of uniform wire is to be drawn, a plate with one or more jewelled holes, that is, filled with one or more perforated rubies, sapphires, or chrysolites, can alone be trusted to, because the holes even in the best steel become rapidly wider by the abrasion. Through a hole in a ruby, 0·0033 of an inch in diameter, a silver wire 170 miles long has been drawn, which possessed at the end the very same section as at the beginning; a result determined by weighing portions of equal length, as also by measuring it with a micrometer. The hole in an ordinary draw-plate of soft steel becomes so wide by drawing 14,000 fathoms of brass wire, that it requires to be narrowed before the original sized wire can be again obtained.

Wire, by being diminished one half, one third, one fourth, &c., in diameter, is augmented in length respectively, four, nine, sixteen times, &c. The speed with which it may be prudently drawn out, depends upon the ductility and tenacity of the metal; but may be always increased the more the wire becomes attenuated, because its particles progressively assume more and more of the filamentous form, and accommodate themselves more readily to the extending force. Iron and brass wires, of 0·3 inch in diameter, bear drawing at the rate of from 12 to 15 inches per second; but when of 0·025 ($\frac{1}{40}$) of an inch, at the rate of from 40 to 45 inches in the same time. Finer silver and copper wire may be extended from 60 to 70 inches per second.

By enclosing a wire of platinum within one of silver ten times thicker, and drawing down the compound wire till it be $\frac{1}{300}$ of an inch, a wire of platinum of $\frac{1}{3000}$ of inch will exist in its centre, which may be obtained apart, by dissolving the silver away in nitric acid. This pretty experiment was first made by Dr. Wollaston.

The French draw-plates are so much esteemed, that one of the best of them used to be sold in this country, during the late war, for its weight in silver. The holes are formed with a steel punch; being made large on that side where the wire enters, and diminishing with a regular taper to the other side. In the act of drawing, they must be well supplied with grease for the larger kinds of wire, and with wax for the smaller.

WOAD (*Vouëde*, *Pastel*, Fr.; *Waid*, Germ.; *Isatis tinctoria*, Linn.), the *glastum* of the ancient Gauls and Germans, is an herbaceous plant which was formerly much cultivated, as affording a permanent blue dye, but it has been in modern times well nigh superseded by *indigo*. Pliny says, "A certain plant which resembles *plantago*, called *glastum*, is employed by the women and girls in Great Britain for dyeing their bodies all over, when they assist at certain religious ceremonies; they have then the color of Ethiopians."—*Hist. Nat.* cap. xxii. § 2.

When the arts, which had perished with the Roman empire, were revived, in the middle ages, woad began to be generally used for dyeing blue, and became an object of most extensive cultivation in many countries of Europe. The environs of Toulouse and Mirepoix, in Upper Languedoc, produced annually 40,000,000 pounds of the prepared woad, or pastel, of which 200,000 bales were consumed at Bordeaux. Beruni, a rich manufacturer of this drug, became surety for the payment of the ransom of his king, Francis I., then the prisoner of Charles V. in Spain.

The leaves of woad are fermented in heaps, to destroy certain vegetable principles injurious to the beauty of the dye, as also to elaborate the indigoferous matter present, before they are brought into the market; but they should be carefully watched during this process. Whenever the leaves have arrived at maturity, a point judged of very differently in different countries, they are stripped off the plant, a cropping which is repeated as often as they shoot, being three or four times in Germany, and eight or ten times in Italy. The leaves are dried as quickly as possible, but not so much as to become black: and they are ground before they get quite dry. The resulting paste is laid upon a sloping pavement, with gutters for conducting the juice, which exudes into a tank; the heap being tramped from time to time, to promote the discharge of the juice. The woad ferments, swells, and cracks in many places, which fissures must be closed; the whole being occasionally watered. The fermentation is continued for twenty or thirty days, in cold weather; and if the leaves have been gathered dry, as in Italy, for four months. When the fermented heap has become moderately dry, it is ground again, and put up in cakes of from one to three pounds; which are then fully dried, and packed up in bundles for the market. Many dyers subject the pastel to a second fermentation.

1,600 square toises (fathoms) of land afford in two cuttings at least 19,000 pounds of leaves, of which weight four fifths are lost in the fermentation, leaving 3,880 pounds of pastel, in loaves or cakes. When good, it has rather a yellow, or greenish-yellow, than a blue color: it is light, and slightly humid; it gives to paper a pale-green trace; and improves by age, in consequence of an obscure fermentation; for if kept four years, it dyes twice as much as after two years. According to Hellot, 4 pounds of Guatimala indigo produce the same effect as 210 pounds of the pastel of Albi. At Quins, in Piedmont, the dyers estimate that 6 pounds of indigo are equivalent to 300 of pastel; but Chaptal thinks the indigo underrated.

Pastel will dye blue of itself, but it is commonly employed as a fermentative addition to the proper blue vat, as described under INDIGO.

Fresh woad, analyzed by Chevreul, afforded, in 100 parts, 65·4 of juice. After being steeped in water, the remaining mass yielded, on expression, 29·65 of liquid; being in whole, 95·05 parts, leaving 4·95 of ligneous fibre. The juice, by filtration, gave 1·95 of green fecula. 100 parts of fresh woad, when dried, are reduced to 13·76 parts. Alcohol, boiled upon dry woad, deposites, after cooling, indigo in microscopic needles; but these cannot be separated from the vegetable albumine, which retains a greenish-gray color.

WOLFRAM is the native tungstate of iron and manganese, a mineral which occurs in primitive formations, along with the ores of tin, antimony, and lead, in the Bohemian Erzegebirge, in Cornwall, Switzerland, North America, &c. It is used by chemists for obtaining tungstic acid and tungsten.

WOOD (*Bois*, Fr.; *Holz*, Germ.), is the hard but porous tissue between the pith and the bark of trees and shrubs, through which the chief part of the juices is conducted from the root towards the branches and leaves, during the life of the vegetable. The ligneous fibre is the substance which remains, after the plant has been subjected to the solvent action of ether, alcohol, water, dilute acids, and caustic alkaline leys. It is considered by chemists that dry timber consists, on an average, of 96 parts of fibrous, and 4 of soluble matter, in 100; but that these proportions vary somewhat with the seasons, the soil, and the plant. All kinds of wood sink in water, when placed in a basin of it under the exhausted receiver of an air-pump; showing their specific gravity to be greater than 1·000. That of fir and maple is stated, by chemical authors, to be 1·46; and that of oak and beech, at 1·53; but I believe them to have all the same spec. grav. as the fibre of flax; namely, 1·50, as determined by me some years ago.*

Wood becomes snow-white, when exposed to the action of chlorine; digested with sulphuric acid, it is transformed first into gum, and, by ebullition with water, afterwards into grape-sugar; with concentrated nitric acid, it grows yellow, loses its coherence, falls into a pulverulent mass, but eventually dissolves, and is converted into oxalic acid; with strong caustic alkaline leys, in a hot state, it swells up excessively, dissolves into a homogeneous liquid, and changes into a blackish-brown mass, containing oxalic and acetic acids.

The composition of wood has been examined by Gay Lussac and Thenard, and Dr. Prout. The first two chemists found it to consist, in 100 parts, of—

	Oak.	Beech.
Carbon - - - -	52·53	51·45
Hydrogen - - -	5·69	5·82
Oxygen - - - -	41·78	42·73

According to Dr. Prout, the oxygen and hydrogen are in the exact proportions to form water. Willow contains 50, and box 49·8 per cent. of carbon; each containing, therefore, very nearly 44·444 of oxygen, and 5·555 of hydrogen. In the analyses of Gay Lussac and Thenard, there is a great excess of hydrogen above what the oxygen requires to form water. Authenrieth stated, some years ago, that he found that fine sawdust, mixed with a sufficient quantity of wheat flour, made a coherent dough with water, which formed an excellent food for pigs; apparently showing that the digestive organs of this animal could operate the same sort of change upon wood as sulphuric acid does.

TABLE of the DISTILLATION of ONE POUND of WOOD, dried, at 86° Fahr.

Name of the wood.	Weight of wood acid.	One ounce of the acid saturates of carbonate of potash.	Weight of the combustible oil.	Weight of the charcoal.
	Ounces.	*Grains.*	*Ounces.*	*Ounces.*
White birch - - - -	7	44	1¼	3¾
Red beech - - -	7	44	1½	3¾
Prick wood (spindle tree) -	7½	40	1¾	3½
Large leaved linden - -	6¾	41	2	3¾
Red or scarlet oak - -	7	40	1½	4½
White beech - - -	6½	40	1¾	3¾
Common ash - - -	7½	34	1½	3½
Horse chestnut - - -	7½	31	1½	3½
Italian poplar - - -	7¼	30	1½	3¾
Silver poplar - - -	7¼	30	1¼	3¾
White willow - - -	7¼	28	1½	3½
Root of the sassafras laurel	6¾	29	1¾	4¼
Wild service tree - - -	7	28	1¾	3½
Basket willow - - -	8	27	1½	3½
Dogberry tree - - -	7	27	2	3½
Buckthorn - - -	7½	26	1½	3½
Logwood - - - - -	7¾	26	1½	4
Alder - - - - -	7¼	22	1½	3½
Juniper - - - - -	7¼	23	1¾	3½
White fir (deal) - -	6½	23	2¼	3½
Common pine wood - -	6¾	22	1¾	3½
Savine tree - - -	7	20	1¾	3¾
Red deal (pine) - - -	6	18	2¼	3¾
Guiac wood - - - -	6	16	2½	4

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* "From the small difference found by experiment between the specific gravity of flax (1·50) and of cotton (1·47), I am inclined to think that the density of both may be considered to be equal," or 1·50.—*Philosophy of Manufactures*, 2d edition, pp. 97, 98, 99.

WOOF is the same as **WEFT.**

WOOLLEN MANUFACTURE. In reference to textile fabrics, sheep's wool is of two different sorts, the short and the long stapled; each of which requires different modes of manufacture in the preparation and spinning processes, as also in the treatment of the cloth after it is woven, to fit it for the market. Each of these is, moreover, distinguished in commerce by the names of fleece wools and dead wools, according as they have been shorn at the usual annual period from the living animal, or are cut from its skin after death. The latter are comparatively harsh, weak, and incapable of imbibing the dyeing principles, more especially if the sheep has died of some malignant distemper. The annular pores, leading into the tubular cavities of the filaments, seem, in this case, to have shrunk and become obstructed. The time of year for sheep-shearing most favorable to the quality of the wool, and the comfort of the animal, is towards the end of June and beginning of July;—the period when Lord Leicester holds his celebrated rural fête for that interesting purpose.

The wool of the sheep has been surprisingly improved by its domestic culture. The *mouflon* (*Ovis aries*), the parent stock from which our sheep is undoubtedly derived, and which is still found in a wild state upon the mountains of Sardinia, Corsica, Barbary, Greece, and Asia Minor, has a very short and coarse fleece, more like hair than wool. When this animal is brought under the fostering care of man, the rank fibres gradually disappear; while the soft wool round their roots, little conspicuous in the wild animal, becomes singularly developed. The male most speedily undergoes this change, and continues ever afterwards to possess far more power in modifying the fleece of the offspring, than the female parent. The produce of a breed from a coarse-woolled ewe and a fine-woolled ram is not of a mean quality between the two, but half-way nearer that of the sire. By coupling the female thus generated with such a male as the former, another improvement of one half will be obtained, affording a staple three fourths finer than that of the grandam. By proceeding inversely, the wool would be as rapidly deteriorated. It is, therefore, a matter of the first consequence in wool husbandry, to exclude from the flock all coarse-fleeced rams.

Long wool is the produce of a peculiar variety of sheep, and varies in the length of its fibres from 3 to 8 inches. Such wool is not carded like cotton, but combed like flax, either by hand or appropriate machinery. Short wool is seldom longer than 3 or 4 inches; it is susceptible of carding and felting, by which processes the filaments become first convoluted, and then densely matted together. The shorter sorts of the combing wool are used principally for hosiery, though of late years the finer kinds have been extensively worked up into Merino and mousseline-de-laine fabrics. The longer wools of the Leicestershire breed are manufactured into hard yarns, for worsted pieces, such as waistcoats, carpets, bombazines, poplins, crapes, &c.

The wool of which good broadcloth is made should be not only shorter, but, generally speaking, finer and softer than the worsted wools, in order to fit them for the fulling process. Some wool-sorters and wool-staplers acquire by practice great nicety of discernment in judging of wools by the touch and traction of the fingers. Two years ago, I made a series of observations upon different wools, and published the results. The filaments of the finer qualities varied in thickness from $\frac{1}{1100}$ to $\frac{1}{1500}$ of an inch; their structure is very curious, exhibiting, in a good achromatic microscope, at intervals of about $\frac{1}{500}$ of an inch, a series of serrated rings, imbricated towards each other, like the joints of *Equisetum*, or rather like the scaly zones of a serpent's skin. See *Philosophy of Manufactures*, figs. 11, 12, page 91, second edition.

There are four distinct qualities of wool upon every sheep; the finest being upon the spine, from the neck to within 6 inches of the tail, including one third of the breadth of the back; the second covers the flanks between the thighs and the shoulders; the third clothes the neck and the rump; and the fourth extends upon the lower part of the neck and breast down to the feet, as also upon a part of the shoulders and the thighs, to the bottom of the hind quarter. These should be torn asunder, and sorted, immediately after the shearing.

The harshness of wools is dependant not solely upon the breed of the animal, or the climate, but is owing to certain peculiarities in the pasture, derived from the soil. It is known, that in sheep fed upon chalky districts, wool is apt to get coarse; but in those upon a rich loamy soil, it becomes soft and silky. The ardent sun of Spain renders the fleece of the Merino breed harsher than it is in the milder climate of Saxony. Smearing sheep with a mixture of tar and butter is deemed favorable to the softness of their wool.

All wool, in its natural state, contains a quantity of a peculiar potash-soap, secreted by the animal, called in this country the *yolk;* which may be washed out by water alone, with which it forms a sort of lather. It constitutes from 25 to 50 per cent. of the wool, being most abundant in the Merino breed of sheep; and however favorable to the growth of the wool on the living animal, should be taken out soon after it is shorn, lest it injure the fibres by fermentation, and cause them to become hard and brittle. After being washed in water, somewhat more than lukewarm, the wool should be well pressed, and carefully dried. England grows annually about 1,000,000 packs of wool, and imports 100,000 bags.

Wool imported into the United Kingdom, in 1836, 64,239,977 lbs.; in 1837, 48,356,121 lbs. Retained for home consumption, in 1836, 60,724,795 lbs.; in 1837, 43,148,297 lbs. Duty received, in 1836, £190,075; in 1837, £118,519.

Having premised these general observations on wool, I shall now proceed to treat of its manufacture, beginning with that of wool-combing, or

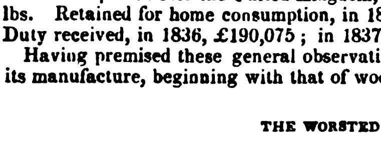
THE WORSTED MANUFACTURE.

In this branch of business, a long stapled and firm fibre is required to form a smooth level yarn, little liable to shrink, curl, or felt in weaving and finishing the cloth. It must not be entangled by carding, but stretched in lines as parallel as possible, by a suitable system of *combing*, manual or mechanical.

When the long wool is brought into the worsted factory, it is first of all washed by men with soap and water, who are paid for their labor by the piece, and are each assisted by a boy, who receives the wool as it issues from between the drying *squeezers*, (see BLEACHING.) The boy carries off the wool in baskets, and spreads it evenly upon the floor of the drying-room, usually an apartment over the boilers of the steam-engine, which is thus economically heated to the proper temperature. The health of the boys employed in this business is found to be not at all injured.

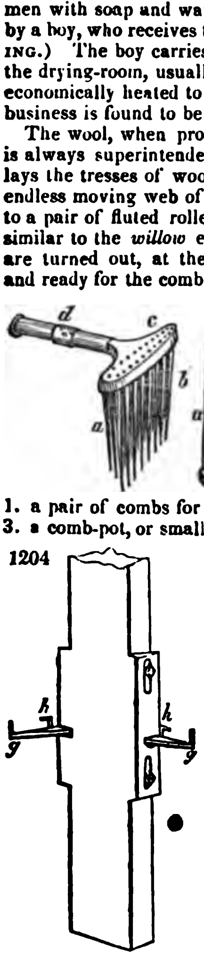
The wool, when properly dried, is transferred to a machine called the *plucker*, which is always superintended by a boy of 12 or 14 years of age, being very light work. He lays the tresses of wool pretty evenly upon the feed-apron, or table covered with an endless moving web of canvass, which, as it advances, delivers the ends of the long tufts to a pair of fluted rollers, whence it is introduced into a fanning apparatus, somewhat similar to the *willow* employed in the cotton manufacture, which see. The filaments are turned out, at the opposite end of this winnowing machine, straightened, cleaned, and ready for the combing operation. According to the old practice of the trade, and still for the finer descriptions of the long staple, according to the present practice, the wool is carded by hand. This is far more severe labor than any subservient to machinery, and is carried on in rooms rendered close and hot by the number of stoves requisite to heat the combs, and so enable them to render the fibres soft, flexible, and elastic. This is a task at which only robust men are engaged. They use three implements; 1. a pair of combs for each person; 2. a post, to which one of the combs can be fixed; 3. a comb-pot, or small stove for heating the teeth of the combs. Each comb is composed either of two or three rows of pointed tapering steel teeth *b*, *fig.* 1203, disposed in two or three parallel planes, each row being a little longer than the preceding. They are made fast at the roots to a wooden stock or head *c*, which is covered with horn, and has a handle *d*, fixed into it at right angles to the lines of the teeth. The spaces between these two or three planes of teeth, is about one third of an inch at their bottoms, but somewhat more at their tips. The first combing, when the fibres are most entangled, is performed with the two-row toothed combs; the second, or finishing combing, with the three-row toothed.

1203



In the workshop a post is planted (*fig.* 1204), upright, for resting the combs occasionally upon, during the operation. An iron stem *g*, projects from it horizontally, having its end turned up, so as to pass through a hole in the handle of the comb. Near its point of insertion into the post, there is another staple point *h*, which enters into the hollow end of the handle; which, between these two catches, is firmly secured to the post. The stove is a very simple affair, consisting merely of a flat iron plate, heated by fire or steam, and surmounted with a similar plate, at an interval sufficient to allow the teeth to be inserted between them at one side, which is left open, while the space between their edges, on the other sides, is closed to confine the heat.

1204



In combing the wool, the workman takes it up in tresses of about four ounces each, sprinkles it with oil, and rolls it about in his hands, to render all the filaments equally unctuous. Some harsh dry wools require one sixteenth their weight of oil, others no more than a fortieth. He next attaches a heated comb to the post, with its teeth pointed upwards, seizes one half of the tress of wool in his hands, throws it over the teeth, then draws it through them, and thus repeatedly, leaving a few straight filaments each time upon the comb. When the comb has in this way collected all the wool, it is placed with its points inserted into the cell of the stove, with the wool hanging down outside, exposed to the influence of the heat. The other comb, just removed in a heated state from the stove, is planted upon the post, and furnished in its turn with the remaining two-ounce tress of wool; after which it supplants the preceding at the stove. Having both combs now hot, he holds one of them with his left hand over his knee, being seated upon a low stool, and seizing the other with his right hand, he combs the wool upon the first, by introducing the teeth of one comb into the wool stuck in the other, and drawing them through it. This manipulation is skilfully repeated, till the fibres are laid truly parallel, like a flat tress of hair. It is proper to begin by combing the tips of the tress, and to advance progressively, from the one end towards the other, till at length the combs are worked with their teeth as closely together as is possible, without bringing them into collision. If the workman proceeded otherwise, he would be apt to rupture the filaments, or tear their ends entirely out of one of the combs. The flocks left at the end of the process, because they are too short for the comber to grasp them in his hand, are called *noyls*. They are unfit for the worsted spinner, and are reserved for the coarse cloth manufacture.

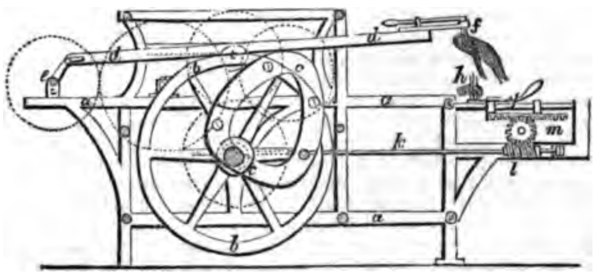
The wool finally drawn off from the comb, though it may form a uniform tress of straight filaments, must yet be combed again at a somewhat lower temperature, to prepare it perfectly for the spinning operation. From ten to twelve slivers are then arranged in one parcel.

To relieve the workman from this laborious and not very salubrious task, has been the object of many mechanical inventions. One of these, considerably employed in this country and in France, is the invention of the late Mr. John Collier, of Paris, for which a patent was obtained in England, under the name of John Platt, of Salford, in November, 1827. It consists of two comb-wheels, about ten feet in diameter, having hollow iron spokes filled with steam, in order to keep the whole apparatus at a proper combing heat. The comb forms a circle, made fast to the periphery of the wheel, the teeth being at right angles to the plane of the wheel. The shafts of the two wheels are mounted in a strong frame of cast iron; not, however, in horizontal positions, but inclined at acute angles to the horizon, and in planes crossing each other, so that the teeth of one circular comb sweep with a steady obliquity over the teeth of the other, in a most ingenious manner, with the effect of combing the tresses of wool hung upon them. The proper quantity of long wool, in its ordinary state, is stuck in handfuls upon the wheel, revolving slowly, by a boy, seated upon the ground at one side of the machine. Whenever the wheel is dressed, the machine is made to revolve more rapidly, by shifting its driving-band on another pulley; and it is beautiful to observe the delicacy and precision with which it smooths the tangled tress. When the wools are set in rapid rotation, the loose ends of the fleece, by the centrifugal force, are thrown out, in the direction of radii, upon the teeth of the other revolving comb-wheel, so as to be drawn out and made truly straight. The operation commences upon the tips of the tresses, where the wheels, by the oblique posture of their shafts, are at the greatest distance apart; but as the planes slowly approach to parallelism, the teeth enter more deeply into the wool, till they progressively comb the whole length of its fibres. The machines being then thrown out of gear, the teeth are stripped of the tresses by the hand of the attendant; the *noyls*, or short refuse wool, being also removed, and kept by itself.

This operation being one of simple superintendence, not of handicraft effort and skill, like the old combing of long wool, is now performed by boys or girls of 13 and 14 years of age; and places in a striking point of view the influence of automatic mechanism, in so embodying dexterity and intelligence in a machine, as to render the cheap and tractable labor of children a substitute for the high-priced and often refractory exertions of workmen too prone to capricious combinations. The chief precaution to be taken with this machine, is to keep the steam-joints tight, so as not to wet the apartments, and to provide due ventilation for the operatives.

The following machine, patented by James Noble, of Halifax, worsted-spinner, in February, 1834, deserves particular notice, as its mode of operation adapts it well also for hackling flax. In *fig.* 1205 the internal structure is exhibited. The frame-work *a*, *a*, supports the axle of a wheel, *b*, *b*, in suitable bearings on each side. To the face of this wheel is affixed the eccentric or heart-wheel cam *c*, *c*. On the upper part of the periphery of this cam or heart-wheel, a lever *d*, *d*, bears merely by its gravity; one end of which lever is connected by a joint to the crank *e*. By the rotation of the crank *e*, it will be perceived that the lever *d*, will be slidden to and fro on the upper part of the periphery of the eccentric or heart-wheel cam *c*, the outer end of the lever *d*, carrying

1205



the upper or working comb or needle-points *f*, as it moves, performing an elliptical curve, which curve will be dependant upon the position of the heart-wheel cam *c*, that guides it. A moveable frame *g*, carries a series of points *h*, which are to constitute the lower comb or frame of needles. Into these lower needles the rough uncombed wool is to be fed by hand, and to be drawn out and combed straight by the movements of the upper or working comb.

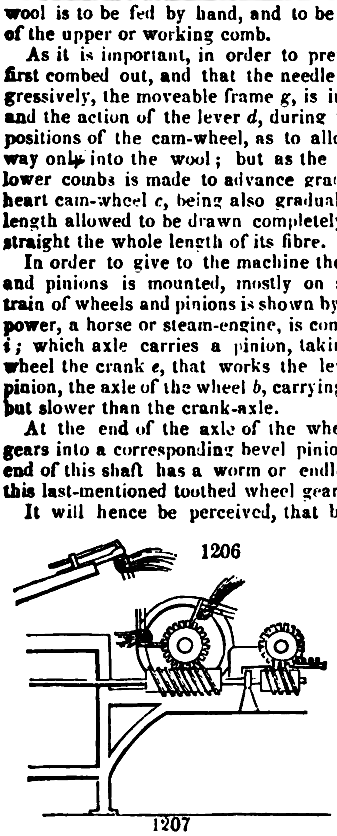
As it is important, in order to prevent waste, that the ends of the wool should be first combed out, and that the needle-points should be made to penetrate the wool progressively, the moveable frame *g*, is in the first instance placed as far back as possible; and the action of the lever *d*, during the whole operation, is so directed by the varying positions of the cam-wheel, as to allow the upper comb to enter at first a very little way only into the wool; but as the operation of combing goes on, the frame with the lower combs is made to advance gradually, and the relative positions of the revolving heart cam-wheel *c*, being also gradually changed, the upper or working needles are at length allowed to be drawn completely through the wool, for the purpose of combing out straight the whole length of its fibre.

In order to give to the machine the necessary movements, a train of toothed wheels and pinions is mounted, mostly on studs attached to the side of the frame; which train of wheels and pinions is shown by dots in the figure, to avoid confusion. The driving power, a horse or steam-engine, is communicated by a band to a rigger on the short axle *i*; which axle carries a pinion, taking into one of the wheels of the train. From this wheel the crank *e*, that works the lever *d*, is driven; and also by gear from the same pinion, the axle of the wheel *b*, carrying the eccentric or heart-wheel cam, is also actuated, but slower than the crank-axle.

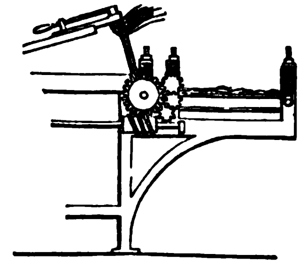
At the end of the axle of the wheel *b*, and cam *c*, a bevel pinion is affixed, which gears into a corresponding bevel pinion on the end of the lateral shaft *k*. The reverse end of this shaft has a worm or endless screw *l*, taking into a toothed wheel *m*; and this last-mentioned toothed wheel gears into a rack at the under part of the frame *g*.

It will hence be perceived, that by the movements of the train of wheels, a slow motion is given to the frame *g*, by which the lower needles carrying the wool are progressively advanced as the operation goes on; and also, that by the other wheels of the train, the heart-wheel cam is made to rotate, for the purpose of giving such varying directions to the stroke of the lever which slides upon its periphery, and to the working comb, as shall cause the comb to operate gradually upon the wool as it is brought forward. The construction of the frames which hold the needles, and the manner of fixing them in the machine, present no features of importance; it is therefore unnecessary to describe them farther, than to say, that the heckles are to be heated when used for combing wool. Instead of introducing the wool to be combed into the lower needles by hand, it is sometimes fed in, by means of an endless feeding-cloth, as shown in *fig.* 1206. This endless cloth is distended over two rollers, which are made to revolve, for the purpose of carrying the cloth with the wool forward, by means of the endless screw and pinions.

1206



1207



A slight variation in the machine is shown at *fig.* 1207, for the purpose of combing wool of long fibre, which differs from the former only in placing the combs or needle points upon a revolving cylinder or shaft. At the end of the axle of this shaft there is a toothed wheel, which is actuated by an endless screw upon a lateral shaft. The axle of the cylinder on which the needles are fixed, is mounted in a moveable frame or carriage, in order that the points of the needles may, in the first instance, be brought to act upon the ends of the wool only, and ultimately be so advanced as to enable the whole length of the fibres to be drawn through. The progressive advancement of this carriage, with the needle cylinder, is effected by the agency of the endless screw on the lateral shaft before mentioned.

Some combing-machines reduce the wool into a continuous sliver, which is ready for the drawing-frame; but the short slivers produced by the hand combing, must be first joined together, by what is called *planking*. The slivers are rolled up by the combers ten or twelve together, in balls called tops, each of which weighs half a pound. At the spinning-mill these are unrolled, and the slivers are laid on a long plank or trough, with the ends lapping over, in order to splice the long end of one sliver into the short end of another. The long end is that which was drawn off first from the comb, and contains the longer fibres; the short is that which comes last from the comb, and contains the shorter. The wool-comber lays all the slivers of each ball the same way, and marks the long end of each by twisting up the end of the sliver. It is a curious circumstance, that when a top or ball of slivers is unrolled and stretched out straight, they will not separate from each other without tearing and breaking, if the separation is begun at the short ends; but if they are first parted at the long ends, they will readily separate.

The machine for combing long wool, for which Messrs. Donisthorpe and Rawson obtained a patent in April, 1835, has been found to work well, and therefore merits a detailed description :—

1208

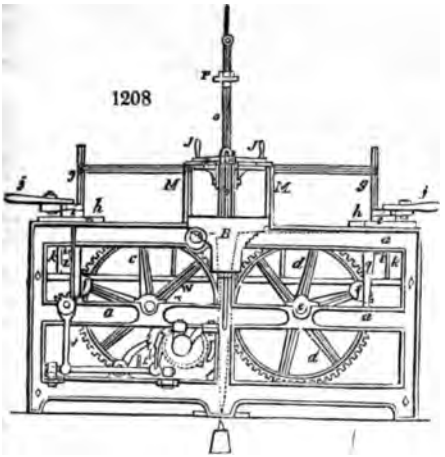
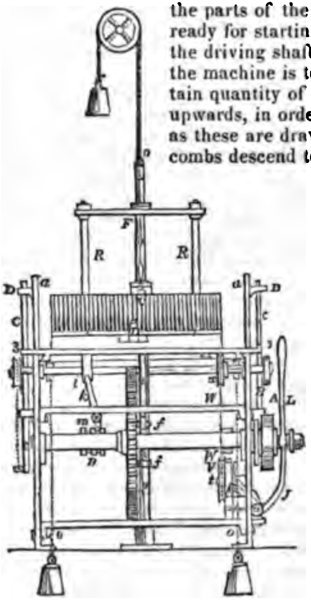


Fig. 1208, is an elevation; *fig.* 1209 an end view; and *fig.* 1210 a plan; in which *a*, *a*, is the framing; *b*, the main shaft, bearing a pinion which drives the wheel and shaft *c*, in gear with the wheel *d*, on the shaft *e*. Upon each of the wheels *c* and *d*, there are two projections or studs *f*, which cause the action of the combs *g*, *g*, of which *h*, *h*, are the tables or carriages. These are capable of sliding along the upper guide rails of the framing *a*. Through these carriages or tables *h*, *h*, there are openings or slits, shown by dotted lines, which act as guides to the holders *i*, *i*, of the combs *g*, *g*, rendering the holders susceptible of motion at right angles to the course pursued by the tables *h*. The combs are retained in the holders *i*, *i*, by means of the lever handles *j*, *j*, which move upon inclined surfaces, and are made to press on the surface of the heads of the combs *g*, *g*, so as to be retained in their places; and they are also held by studs affixed to the holders, which pass into the comb-heads. From the under side of the tables, forked projections *i*, *i*, stand out, which pass through the openings or slits formed in the tables *h h*; these projections are worked from side to side by the frame *k*, *k*, which turning on the axis or shaft *l*, *l*, is caused to vibrate, or rock to and fro, by the arms *m*, moved by the eccentric groove *n*, made fast to the shaft *e*. The tables *h*, are drawn inwards, by weights suspended on cords or straps *o*, *o*, which pass over friction pulleys *p*, *p*; whereby the weights have a constant tendency to draw the combs into the centre of the machine, as soon as it is released by the studs *f*, passing beyond the projecting arms *g*, on the tables. On the shaft *c*, a driving-tooth or catch *r*, is fixed, which takes into the ratchet wheel *s*, and propels one of its teeth at every revolution of the shaft *c*. This ratchet wheel turns on an axis at *t*; to the ratchet the pulley *v* is made fast, to which the cord or band *w* is secured, as also to the pulley *x*, on the shaft *y*. On the shaft *y*, there are two other pulleys *z*, *z*, having the cords or bands A, A, made fast to them, and also to the end of the gauge-plates B, furnished with graduated steps, against which the tables *h*, *h*, are drawing at each operation of the machine. In proportion as these gauge-plates are raised, the nearer the carriages or tables *h*, will be able to advance to the centre of the machine, and thus permit the combs *g*, *g*, to lay hold of, and comb, additional lengths of the woolly fibres. The gauge-plates B, are guided up by the bars C, which pass through openings, slots, or guides, made in the framing *a*, as shown by D.

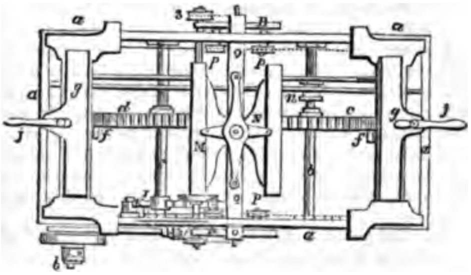
To the ratchet wheel *s*, an inclined projection E, is made fast, which in the course of the rotation of the ratchet wheel, comes under the lever F, fixed to the shaft G, that turns in bearings H. To this shaft the levers I and J, are also fixed; I serving to throw out the click or catch K, from the ratchet wheel, by which the parts of the machine will be released, and restored to positions ready for starting again. The lever J, serves to slide the drum upon the driving shaft *b*, out of gear, by means of the forked handle L, when the machine is to be stopped, whenever it has finished combing a certain quantity of wool. The combs which hold the wool have a motion upwards, in order to take the wool out of the way of the combs *g*, *g*, as these are drawn into the centre of the machine; while the holding combs descend to lay the wool among the points of the combs *g*, *g*. For obtaining this upward and downward motion, the combs M, M, are placed upon the frame N, and retained there just as the combs *g*, *g*, are upon the holders *i*, *i*. The framing N is made fast to the bar or spindle O, which moves vertically through openings in the cross-head P, and the cross-framing of the machine Q; from the top of which, there is a strap passes over pulleys with a weight suspended to it; the cross-head being supported by the two guide-rods R, fixed to the cross-framing Q. It is by the guide-rods R, and the spindle O, that the frame N is made to move up and down; while the spindle is made to rise by the studs *f*, as the wheels *c* and *d* come successively under the studs *s*, on the spindle O.

1209



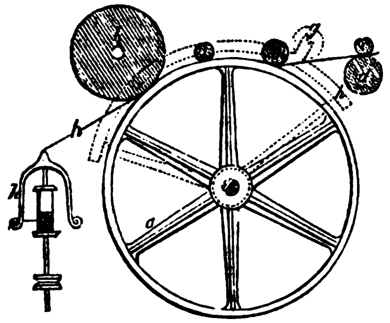
A quantity of wool is to be placed on each of the combs *g*, *g*, and M, M, the machine being in the position shown in *fig.* 1210. When the main shaft *b*, is set in motion, it will drive by its pinion the toothed wheel *c*, and therefrom the remaining parts of the machine. The first effect of the movement will be to raise the combs M, M, sufficiently high to remove the wood out of the way of the combs *g*, *g*, which will be drawn towards the centre of the machine, as soon as they are released by the studs *f*, passing the projecting arms *q*, on the tables *h*; but the distance between the combs *g*, *g*, and the combs H, H, will depend on the height to which the gauge-plates B, have been raised. These plates are raised one step at each revolution of the shaft *c*; the combs *g*, *g*, will therefore be continually approaching more nearly to the combs M, M, till the plates B, are so much raised as to permit the tables *h*, to approach the plates B, below the lowest step or graduation, when the machine will continue to work. Notwithstanding the plates B, continuing to rise, there being only parallel surfaces against which the tables come, the combs *g*, *g*, will successively come to the same position, till the inclined projection E, on the ratchet wheel *s*, comes under the lever F, which will stop the machine. The wool which has been combed is then to be removed, and a fresh quantity introduced. It should be remarked, that the combs *g*, *g*, are continually moving from side to side of the machine, at the same time that they are combing out the wool. The chief object of the invention is obviously to give the above peculiar motions to the combs *g*, *g*, and M, M; which may be applied also to combing goat-hair.

1210



For the purposes of the worsted manufacture, wool should be rendered inelastic to a considerable degree, so that its fibres may form long lines, capable of being twisted into straight level yarn. Mr. Bayliffe, of Kendal, has sought to accomplish this object, first, by introducing into the *drawing* machine a rapidly revolving wheel, in contact with the front drawing roller, by whose friction the filaments are heated, and at the same time deprived of their curling elasticity; secondly, by employing a moveable regulating roller, by which the extent of surface on the periphery of the wheel that the lengths of wool is to act upon, may be increased or diminished at pleasure, and, consequently, the effect regulated or tempered as the quality of the wool may require; thirdly, the employment of steam in a rotatory drum, or hollowed wheel, in place of the wheel first described, for the purpose of heating the wool, in the process of drawing, in order to facilitate the operation of straightening the fibres.

1211



These objects may be effected in several ways; that is, the machinery may be variously constructed, and still embrace the principles proposed. *Fig.* 1211, shows one mode: — *a*, is the friction wheel; *b*, the front drawing roller, placed in the drawing frame in the same way as usual; the larger wheel *a*, constituting the lower roller of the pair of front drawing rollers; *c*, and *d*, are the pair of back drawing rollers, which are actuated by gear connected to the front rollers, as in the ordinary construction of drawing machines, the front rollers moving very considerably faster than the back rollers, and, consequently, drawing or extending the fibres of the sliver of wool, as it passes through between them; *e*, is a guide roller, bearing upon the periphery of the large wheel; *f*, is a tension roller, which presses the fibres of the wool down upon the wheel *a*.

Now, supposing the back rollers *c* and *d* to be turned with a given velocity, and the front roller *b* to be driven much faster, the effect would be, that the fibres of wool constituting the sliver, passing through the machine, would be considerably extended between *b* and *d*, which is precisely the effect accomplished in the ordinary drawing frame; but the wheel *a*, introduced into the machine in place of the lower front drawing roller, being made to revolve much faster than *b*, the sliver of wool extended over the upper part of its periphery from *b*, to the tension roller *f*, will be subjected to very considerable friction from the contact; and, consequently, the natural curl of the wool will be taken out, and its elasticity destroyed, which will enable the wool to proceed in a connected roving down to the spindle or flier *h*, where it becomes twisted or spun into a worsted thread.

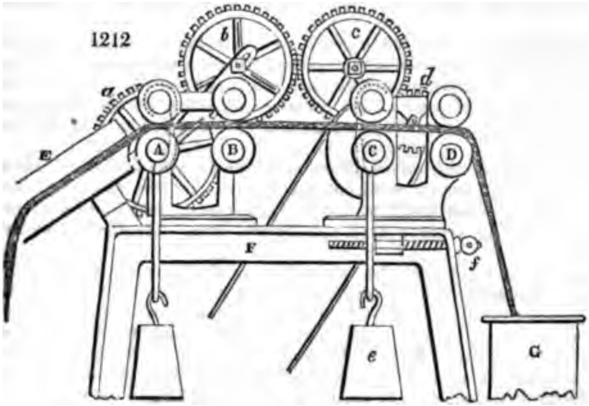
In order to increase or diminish the extent to which the fibres of wool are spread over the periphery of the wheel *a*, a regulating roller is adapted to the machine, as shown at *g*, in place of the tension roller *f*. This regulating roller *g*, is mounted by its pivots in bearings on the circular arms *h*, shown by dots. These circular arms turn loosely upon the axle of the wheel *a*, and are raised or depressed by a rack and a winch, not shown in the figure; the rack taking into teeth on the periphery of the circular arms. It will hence be perceived, that by raising the circular arms, the roller *g*, will be carried backward, and the fibres of wool pressed upon the periphery of the wheel to a greater extent. On the contrary, the depression of the circular arms will draw the roller *g*, forward, and cause the wool to be acted upon by a smaller portion of the periphery of the wheel *a*, and consequently subject it to less friction.

When it is desired to employ steam for the purpose of heating the wool, the wheel *a*, is formed as a hollow drum, and steam from a boiler, in any convenient situation, is conveyed through the hollow axle to the interior of the drum, which, becoming heated by that means, communicates heat also to the wool, and thereby destroys its curl and elasticity.

Breaking-frame.—Here the slivers are *planked*, or spliced together, the long end of one to the short end of another; after which they are drawn out and extended by the rollers of the breaking frame. A sketch of this machine is given in *fig.* 1212. It consists of 4 pairs of rollers, A, B, C, D. The first pair A, receives the wool from the inclined trough E, which is the planking-table. The slivers are unrolled, parted, and hung loosely over a pin, in reach of the attendant, who takes a sliver, and lays it flat in the trough, and the end is presented to the rollers A, which being in motion, will draw the wool in; the sliver is then conducted through the other rollers, as shown in the figure: when the sliver has passed half through, the end of another sliver is placed upon the middle of the first, and they pass through together; when this second is passed half through, the end of a third is applied upon the middle of it, and in this way the short slivers produced by the combing are joined into one regular and even sliver.

The lower roller C receives its motion from the mill, by means of a pulley upon the end of its axis, and an endless strap. The roller which is immediately over it, is borne down by a heavy weight, suspended from hooks, which are over the pivots of the upper roller. The fourth pair of rollers D, moves with the same velocity as C, being turned by means of a small wheel upon the end of the axis of the roller C, which turns a wheel of the same size upon the axis of the roller D, by means of an intermediate wheel *d*, which makes both rollers turn the same way round. The first and second pairs of rollers, A and B, move only one third as quick as C and D, in order to draw out the sliver between B and C to three times the length it was when put on the planking-table. The slow motion of the rollers A, is given by a large wheel *a*, fixed upon the axis of the roller A, and turned by the intermediate cog-wheels *b*, *c*, and *d*; the latter communicates between the rollers C and D. The pinions on the rollers C and D being only one third the size of the wheel *a*, C and D turn three times as fast as A, for *b*, *c*, and *d*, are only intermediate wheels. The rollers B turn at the same rate as A. The upper roller C is loaded with a heavy weight, similar to the rollers A; but the other rollers, B and D, are no further loaded than the weight of the rollers.

1212



The two pairs of rollers A, B, and C, D, are mounted in separate frames; and that frame which contains the third and fourth pairs C, D, slides upon the cast-iron frame F, which supports the machine, in order to increase or diminish the distance between the rollers B and C. There is a screw *f*, by which the frame of the rollers is moved, so as to adjust the machine according to the length of the fibre of the wool. The space between B and C should be rather more than the length of the fibres of the wool. The intermediate wheels *b* and *c*, are supported upon pieces of iron, which are moveable on centres; the centre for the piece which supports the wheel *b* is concentric with the axis of the roller A; and the supporting piece for the wheel *c* is fitted on the centre of the wheel *d*. By moving these pieces the intermediate wheels *b* and *c* can be always kept in contact, although the distance between the rollers is varied at times. By means of this breaking-frame, the perpetual sliver, which is made up by planking the sliver together, is equalized, and drawn out three times in length, and delivered into the can G.

Drawing-frame.—Three of these cans are removed to the drawing-frame, which is similar to the breaking-frame, except that there is no planking-table E. There are five sets of rollers, all fixed upon one common frame F, the breaking-frame, which we have described, being the first. As fast as the sliver comes through one set of rollers, it is received into a can, and then three of these cans are put together, and passed again through another set of rollers. In the whole, the wool must pass through the breaker and four drawing-frames before the roving is begun. The draught being usually four times at each operation of drawing, and three times in the breaking, the whole will be $3 \times 4 \times 4 \times 4 \times 4 = 768$; but to suit different sorts of wool, the three last drawing-frames are capable of making a greater draught, even to five times, by changing the pinions; accordingly the draught will be $3 \times 4 \times 5 \times 5 \times 5 = 1500$ times.

The size of the sliver is diminished by these repeated drawings, because only three slivers are put together, and they are drawn out four times; so that, in the whole, the sliver is reduced to a fourth or a ninth of its original bulk.

The breaking-frame and drawing-frame which are used when the slivers are prepared by the combing-machines, are differently constructed; they have no planking-table, but receive three of the perpetual slivers of the combing-machine from as many tin cans, and draw them out from ten to twelve times. In this case, all the four rollers contribute to the operation of drawing: thus the second rollers B, move 2½ times as fast as the rollers A; the third rollers C, move 8 times as fast as A; and the fourth rollers E, move 10½ times as fast as A. In this case, the motion is given to the different rollers by means of bevelled wheels, and a horizontal axis, which extends across the ends of all the four rollers, to communicate motion from one pair of rollers to another.

There are three of these systems of rollers, which are all mounted on the same frame; and the first one through which the wool passes, is called the breaking-frame;

but it does not differ from the others, which are called drawing-frames. The slivers which have passed through one system of rollers, are collected four or five together, and put through the drawing-rollers. In all, the slivers pass through three drawings, and the whole extension is seldom less than 1000 times, and for some kinds of wool much greater.

After the drawing of the slivers is finished, a pound weight is taken, and is measured by means of a cylinder, in order to ascertain if the drawing has been properly conducted; if the sliver does not prove of the length proposed, according to the size of worsted which is intended to be spun, the pinions of some of the drawing-frames are changed, to make the draught more or less, until it is found by experiment that one pound of the sliver measures the required length.

Roving-frame.—This is provided with rollers, the same as the drawing-frames; it takes in one or two slivers together, and draws them out four times. By this extension, the sliver becomes so small, that it would break with the slightest force, and it is therefore necessary to give some twist; this is done by a spindle and flier. See *Roving*, under COTTON MANUFACTURE.

Spinning-frame.—This is so much like the roving-frame, that a short description will be sufficient. The spindles are more delicate, and there are three pairs of rollers, instead of two; the bobbins, which are taken off from the spindles of the roving-frame, when they are quite full, are stuck upon skewers, and the roving which proceeds from them is conducted between the rollers. The back pair turns round slowly; the middle pair turns about twice for once of the back rollers; and the front pair makes from twelve to seventeen turns for one turn of the back roller, according to the degree of extension which is required.

The spindles must revolve very quickly in the spinning-frame, in order to give the requisite degree of twist to the worsted. The hardest twisted worsted is called tammy warp; and when the size of this worsted is such as to be 20 or 24 hanks to the pound weight, the twist is about 10 turns in each inch of length. The least twist is given to the worsted for fine hosiery, which is from 18 to 24 hanks to the pound. The twist is from 5 to 6 turns per inch. The degree of twist is regulated by the size of the whirls or pulleys upon the spindle, and by the wheel-work which communicates the motion to the front rollers from the band-wheel, which turns the spindles.

It is needless to enter more minutely into the description of the spinning machinery, because the fluted roller construction, invented by Sir Richard Arkwright, fully described under COTTON MANUFACTURE, is equally applicable to worsted. The difference between the two is chiefly in the distance between the rollers, which, in the worsted-frame, is capable of being increased or diminished at pleasure, according to the length of the fibres of the wool; and the draught or extension of the roving is far greater than in the cotton.

Reeling.—The bobbins of the spinning-frame are placed in a row upon wires before a long horizontal reel, and the threads from 20 bobbins are wound off together. The reel is exactly a yard in circumference, and when it has wound off 80 turns, it rings a bell; the motion of the reel is then stopped, and a thread is passed round the 80 turns or folds which each thread has made. The reeling is then continued till another 80 yards is wound off, which is also separated by interweaving the same thread; each of these separate parcels is called a ley, and when 7 such leys are reeled, it is called a hank, which contains 560 yards. When this quantity is reeled off, the ends of the binding thread are tied together, to bind each hank fast, and one of the rails of the reel is struck to loosen the hanks, and they are drawn off at the end of the reel. These hanks are next hung upon a hook, and twisted up hard by a stick; then doubled, and the two parts twisted together to make a firm bundle. In this state, the hanks are weighed by a small index machine, which denotes what number of the hanks will weigh a pound, and they are sorted accordingly into different parcels. It is by this means that the number of the worsted is ascertained as the denomination for its fineness: thus No. 24 means, that 24 hanks, each containing 560 yards, will weigh a pound, and so on.

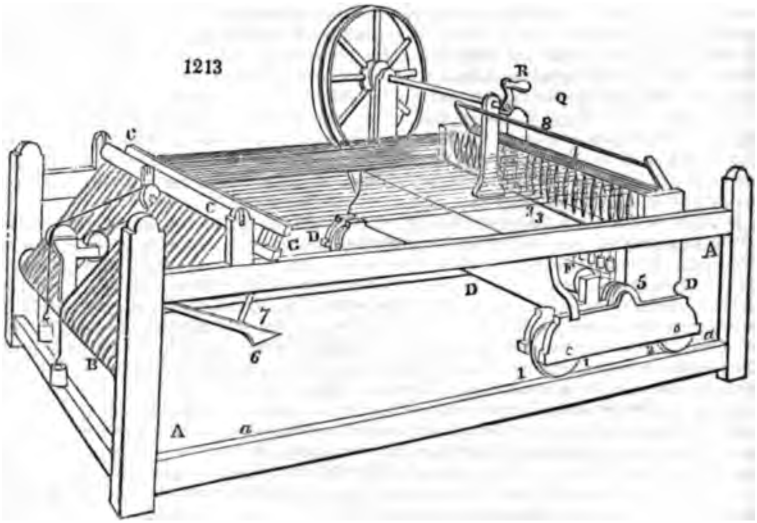
This denomination is different from that used for cotton, because the hank of cotton contains 840 yards, instead of 560; but in some places the worsted hank is made of the same length as the cotton.

To pack up the worsted for market, the proper number of hanks is collected to make a pound, according to the number which has been ascertained; these are weighed, as a proof of the correctness of the sorting, then tied up in bundles of one pound each, and four of these bundles are again tied together. Then 60 such bundles are packed up in a sheet, making a bale of 240 pounds, ready for market.

Of the treatment of short wool for the cloth manufacture.—Short wool resembles cotton not a little in the structure of its filaments, and is cleaned by the *willy*, as cotton is by the *willow*, which opens up the matted fleece of the wool-stapler, and cleans it from accidental impurities. Sheep's wool for working into coarse goods, must be passed repeatedly through this machine, both before and after it is dyed; the second last time for the purpose of blending the different sorts together, and the last for imbuing the fibres intimately with oil. The oiled wool is next subjected to a first carding operation called *scribbling*, whereby it is converted into a broad thin fleece or lap, as cotton is by the breaker-cards of a cotton mill. The woollen lap is then worked by the cards proper, which deliver it in a narrow band or sliver. By this process the wool expands greatly in all its dimensions; while the broken or short filaments get entangled by crossing in every possible direction, which prepares them for the fulling operation. See *Carding*, under COTTON MANUFACTURE.

The *slubbing machine*, or *billy*, reduces the separate rolls of *cardings* into a continuous slightly twisted spongy cord, which is sometimes called a roving. *Fig.* 1213 is a perspective representation of the slubbing machine in most common use. A, A, is the wooden frame; within which is the moveable carriage D, D, which runs upon the lower side rails at *a*, *a*, on friction wheels at 1, 2, to make it move easily backwards and forwards from one end of the frame to the other. The carriage contains a series of steel spindles, marked 3, 3, which receive rapid rotation from a long tin drum F, by means of a series of cords passing round the pulley or whorl of each spindle. This drum, 6 inches in diameter, is covered with paper, and extends across the whole breadth of the carriage. The spindles are set nearly upright in a frame, and about 4 inches apart; their under ends being pointed conically, turn in brass sockets called steps, and are retained in their position by a small brass collet, which embraces each spindle at about the middle of its length. The upper half of each spindle projects above the top of the frame. The drum revolves horizontally before the spindles, having its axis a little below the line of the whorls; and receives motion, by a pulley at one of its ends, from an endless band which passes round a wheel E, like the large domestic wheel formerly used in spinning wool by hand, and of similar dimensions. This wheel is placed upon the outside of the main frame of the machine, and has its shafts supported by upright standards upon the carriage D. It is turned by the spinner placed at Q, with his right hand applied to a winch R, which gives motion to the drum, and thereby causes the spindles to revolve with great velocity.

1213



Each spindle receives a soft cylinder or carding of wool, which comes through beneath a woollen roller C, C, at the one end of the frame. This is the *billy roller*, so much talked of in the controversies between the operatives and masters in the cotton factories, as an instrument of cruel punishment to children, though no such machine has been used in cotton mills for half a century at least. These woollen rolls proceed to the series of spindles, standing in the carriage, in nearly a horizontal plane. By the alternate advance and retreat of the carriage upon its railway, the spindles are made to approach to, and recede from, the roller C, with the effect of drawing out a given length of the soft cord, with any desired degree of twist, in the following manner:—

The carding rolls are laid down straight, side by side, upon the endless cloth, strained in an inclined direction between two rollers, one of which is seen at B, and the other lies behind C. One carding is allotted to a spindle; the total number of each in one machine being from 50 to 100. The roller C, of light wood, presses gently with its weight upon the cardings, while they move onwards over the endless cloth, with the running out of the spindle carriage. Immediately in front of the said roller, there is a horizontal wooden rail or bar G, with another beneath it, placed across the frame. The carding is conducted through between these two bars, the moveable upper one being raised to let any aliquot portion of the roll pass freely. When this bar is again let down, it pinches the spongy carding fast; whence this mechanism is called the clasp. It is in fact the *clove*, originally used by Hargreaves in his cotton-jenny. The moveable upper rail G, is guided between sliders, and a wire 7, descends from it to a lever C. When the spindle carriage D, D, is wheeled close home to the billy roller, a wheel 5, lifts the end 6 of the lever, which, by the wire 7, raises the upper bar or rail G, so as to open the clasp, and release all the card rolls. Should the carriage be now drawn a little way from the clasp bars, it would tend to pull a corresponding length of the cardings forward from the inclined plane B, C. There is a small catch, which lays hold of the upper bar of the clasp G, and hinders it from falling till the carriage has receded to a certain distance, and has thereby allowed from 7 to 8 inches of the cardings to be taken out. A stop upon the carriage then comes against the catch, and withdraws it; thus allowing the upper rail to fall and pinch the carding, while the carriage, continuing to recede, draws out or stretches that portion of the roll which is between the clasp and the spindle points. But during this time the wheel has been turned to keep the spindles revolving, communicating the proper degree of twist to the cardings in proportion to their extension, so as to prevent them from breaking.

It might be imagined that the slubbing cords would be apt to coil round the spindles; but as they proceed in a somewhat inclined direction to the clasp, they receive merely a twisting motion, continually slipping over the points of the spindles, without getting wound upon them. Whenever the operative or slubber has given a due degree of twist to the rovings, he sets about winding them upon the spindles into a conical shape, for which purpose he presses down the faller-wire 8, with his left hand, so as to bear it down from the points of the spindles, and place it opposite to their middle part. He next makes the spindles revolve, while he pushes in the carriage slowly, so as to coil the slubbing upon the spindle into a conical cop. The wire 8, regulates the winding-on of the whole series of slubbings at once, and receives its proper angle of depression for this purpose from the horizontal rail 4, which turns upon pivots in its ends, in brasses fixed on the standards, which rise from the carriage D. By turning this rail on its pivots, the wire 8 may be raised or lowered in any degree. The slubber seizes the rail 4 in his left hand, to draw the carriage out; but in returning it, he depresses the faller-wire, at the same time that he pushes the carriage before him.

The cardings are so exceedingly tender, that they would readily draw out, or even break, if they were dragged with friction upon the endless cloth of the inclined plane. To save this injurious traction, a contrivance is introduced for moving the apron. A cord is applied round the groove in the middle part of the upper roller, and after passing over pulleys, as shown in the figure, it has a heavy weight hung at the one end, and a light weight at the other, to keep it constantly extended, while the heavy weight tends to turn the rollers with their endless cloth round in such a direction as to bring forward the rovings, without putting any strain upon them. Every time that the carriage is pushed home, the larger weight gets wound up; and when the carriage is drawn out, the greater weight turns the roller, and advances the endless apron, so as to deliver the carding at the same rate as the carriage runs out; but when the proper quantity is delivered, a knot in the rope arrives at a fixed stop, which does not permit it to move any further; while at the same instant the roller 5 quits the lever 6, and allows the upper rail G, of the clasp to fall, and pinch the carding fast; the wheel E, being then set in motion, makes the spindles revolve; and the carriage being simultaneously drawn out, extends the slubbings while under the influence of twisting. In winding up the slubbings, the operative must take care to push in the carriage, and to turn the wheel round at such rates that the spindles will not take up faster than the carriage moves on its railway, or he would injure the slubbings. The machine requires the attendance of a child, to bring the cardings from the card-engine, to place them upon the sloping feed-cloth, and to join the ends of the fresh ones carefully to the ends of the others newly drawn under the roller. Slubbings intended for warp-yarn must be more twisted than those for weft; but each must receive a degree of torsion relative to the quality of wool and of the cloth intended to be made. In general, however, no more twist should be given to the slubbings than is indispensable for enabling them to be drawn out to the requisite slenderness without breaking. This twist forms no part of the twist of the finished yarn, for the slubbing will be twisted in the contrary direction, when spun afterwards in the jenny or mule.

I may here remark, that various machines have been constructed of late years for making continuous card-ends, and slubbings, in imitation of the carding and roving of the Cotton Manufacture; to which article I therefore refer my readers. The wool slubbings are now spun into yarn, in many factories, by means of the mule. Indeed, I have seen in France the finest yarn, for the *mousseline-de-laine* fabrics, beautifully spun upon the self-actor mule of Sharp and Roberts.*

Tentering.—When the cloth is returned from the fulling-mill (which see), it is stretched upon the tenter-frame, and left in the open air till dry.

In the woollen manufacture, as the cloth suffers, by the operation of the fulling-mill, a shrinkage of its breadth to well nigh one half, it must at first be woven of nearly double its intended width when finished. Superfine six-quarter broad cloths must therefore be turned out of the loom twelve quarters wide.

Burling is the name of a process, in which the dried cloth is examined minutely in every part, freed from knots or uneven threads, and repaired by sewing any little rents, or inserting sound yarns in the place of defective ones.

Teasling.—The object of this operation is to raise up the loose filaments of the woollen yarn into a nap upon one of the surfaces of the cloth, by scratching it either with thistle-heads, called teasels, or with teasling-cards or brushes, made of wire. The natural teasels are the balls which contain the seeds of the plant called *Dipsacus fullorum;* the scales which form the balls project on all sides, and end in sharp elastic points, that turn downwards like hooks. In teasling by hand, a number of these balls are put into a small wooden frame, having crossed handles, eight or ten inches long; and when thus filled, form an implement not unlike a curry-comb, which is used by two men, who seize the teasel-frame by the handles, and scrub the face of the cloth, hung in a vertical position from two horizontal rails, made fast to the ceiling of the workshop. First, they wet the cloth, and work three times over, by strokes in the direction of the warp, and next of that of the weft, so as to raise all the loose fibres from the felt, and to prepare it for shearing. In large manufactories, this dressing operation is performed by a machine called a gig-mill, which originally consisted, and in most places still consists, of a cylinder bristled all over with the thistle-heads, and made to revolve rapidly while the cloth is drawn over it in a variety of directions. If the thistle be drawn in the line of the warp, the points act more efficaciously upon the weft, being perpendicular to its softer spun yarns. Inventors who have tried to give the points a circular or oblique action between the warp and the weft, proceed apparently upon a false principle, as if the cloth were like a plate of metal, whose substance could be pushed in any direction. Teasling really consists in drawing out one end of the filaments, and leaving the body of them entangled in the cloth; and it should seize and pull them perpendicularly to their length, because in this way it acts upon the ends, which being least implicated, may be most readily disengaged.

When the hooks of the thistles become clogged with flocks of wool, they must be taken out of the frame or cylinder, and cleaned by children with a small comb. Moisture, moreover, softens their points, and impairs their teasling powers; an effect which needs to be counterbalanced, by taking them out, and drying them from time to time. Many contrivances have, therefore, been proposed in which metallic teasels of an unchangeable nature, mounted in rotatory machines, driven by power, have been substituted for the vegetable, which being required in prodigious quantities, becomes sometimes excessively scarce and dear in the clothing districts. In 1818, several schemes of that kind were patented in France, of which those of M. Arnold-Merick, and of MM. Taurin frères, of Elbœuf, are described in the 16th volume of *Brevets d'Invention expirés*. Mr. Daniell, cloth manufacturer in Wilts, renewed this invention under another form, by making his rotatory cards with two kinds of metallic wires, of unequal length; the one set, long, thin, and delicate, representing the points of the thistle; the other, shorter, stiffer, and blunter, being intended to stay the cloth, and to hinder the former from entering too far into it. But none of these processes have succeeded in discarding the natural teasel from the most eminent manufactories.

The French government purchased, in 1807, the patent of Douglas, an English mechanist, who had, in 1802, imported into France the best system of gig-mills then used in the west of England. A working set of his machines having been placed in the *Conservatoire des Arts*, for public inspection, they were soon introduced into most of the French establishments, so as generally to supersede teasling (*lainage*) by hand. A description of them was published in the third volume of the *Brevets d'Invention*. The following is an outline of some subsequent improvements:—

1. As it was imagined that the seesaw action of the hand operative was in some respects more effectual than the uniform rotation of a gig-mill, this was attempted to be imitated by an alternating movement.

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* See this admirable machine fully described and delineated in my *Cotton Manufacture of Great Britain*, vol. ii.

2. Others conceived that the seesaw motion was not essential, but that it was advantageous to make the teasels or cards act in a rectilinear direction, as in working by hand: this action was attempted by placing the two ends of the teasel-frame in grooves formed like the letter D, so that the teasel should act on the cloth only when it came into the rectilinear part. Mr. Wells, machine-maker, of Manchester, obtained a patent, in 1832, for this construction.

3. It was supposed that the teasels should not act perpendicularly to the weft, but obliquely or circularly upon the face of the cloth. Mr. Ferrabee, of Gloucester, patented, in 1830, a scheme of this kind, in which the teasels are mounted upon two endless chains, which traverse from the middle of the web to the selvage or list, one to the right, and another to the left hand, while the cloth itself passes under them with such a velocity, that the effect, or *resultant*, is a diagonal action, dividing into two equal parts the rectangle formed by the weft and warp yarns. Three patent machines of Mr. George Oldland—the first in 1830, the second and third in 1832—all proceed upon this principle. In the first, the teasels are mounted upon discs made to turn flat upon the surface of the cloth; in the second, the rotating discs are pressed by corkscrew spiral springs against the cloth, which is supported by an elastic cushion, also pressed against the discs by springs; and in the third machine, the revolving discs have a larger diameter, and they turn, not in a horizontal, but a vertical plane.

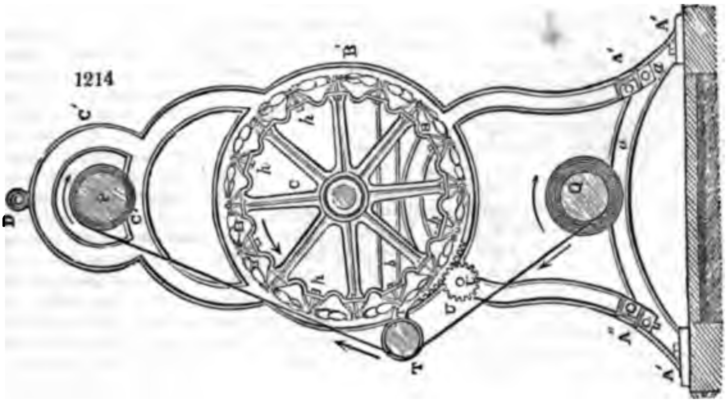
4. Others fancied that it would be beneficial to support the reverse side of the cloth by flat hard surfaces, while acting upon its face with cards, or teasels. Mr. Joseph Cliseld Daniell, having stretched the cloth upon smooth level stones, teasels them by hand. 5. Messrs. Charlesworth and Mellor obtained a patent, in 1829, for supporting the back of the cloth with elastic surfaces, while the part was exposed to the teasling action. 6. Elasticity has also been imparted to the teasels, in the three patent inventions of Mr. Sevill, Mr. J. C. Daniell, and Mr. R. Atkinson. 7. It has been thought useful to separate the teasel-frames upon the drum of the gig-mill, by simple rollers, or by rollers heated with steam, in order to obtain the combined effect of calendering and teasling. Mr. J. C. Daniell, Mr. G. Haden, and Mr. J. Rayner, have obtained patents for contrivances of this kind. 8. Several French schemes have been mounted for making the gig-drum act upon the two sides of the cloth, or even to mount two drums on the same machine.

Mr. Jones, of Leeds, contrived a very excellent method of stretching the cloth, so as to prevent the formation of folds or wrinkles. (See Newton's Journal, vol. viii., 2d series, page 126.) Mr. Collier, of Paris, obtained a patent, in 1830, for a greatly improved gig-mill, upon Douglas's plan, which is now much esteemed by the French clothiers. The following figures and description exhibit one of the latest and best teasling machines. It is the invention of M. Dubois and Co., of Louviers, and is now doing excellent work in that celebrated seat of the cloth manufacture.

In the fulling-mill, the woollen web acquires body and thickness, at the expense of its other dimensions; for being thereby reduced about one third in length, and one half in breadth, its surface is diminished to one third of its size as it comes out of the loom; and it has, of course, increased threefold in thickness. As the filaments drawn forth by teasling are of very unequal lengths, they must be shorn to make them level, and with different degrees of closeness, according to the quality of the stuff, and the appearance it is desired to have. But, in general, a single operation of each kind is insufficient; whence, after having passed the cloth once through the gig-mill and once through the shearing-machine (*tondeuse*), it is ready to receive a second teasling, deeper than the first, and then to suffer a second shearing. Thus, by the alternate repetition of these processes, as often as is deemed proper, the cloth finally acquires its wished-for appearance. Both of these operations are very delicate, especially the first; and if they be ill conducted, the cloth is weakened, so as to tear or wear most readily. On the other hand, if they be skilfully executed, the fabric becomes not only more sightly, but it acquires strength and durability, because its face is changed into a species of fur, which protects it from friction and humidity.

Figs. 1214, 1215, represent the gig-mill in section, and in front elevation. A, B, C, D, A′, B′, C′, D′, being the strong frame of iron, cast in one piece, having its feet enlarged a little more to the inside than to the outside, and bolted to large blocks in the stone pavement. The two uprights are bound together below by two cross-beams A″, being fastened with screw-bolts at the ears *a″*, *a″*; and at top, by the wrought-iron stretcher-rod D, whose ends are secured by screw-nuts at D, D′. The drum is mounted upon a wrought-iron shaft F, which bears at its right end (*fig.* 1215), exterior to the frame, the usual riggers, or fast and loose pulley, *ff′*, *f* which give motion to the machine by a band from the main shaft of the mill. On its right end, within the frame, the shaft F, has a bevel wheel F′, for transmitting movement to the cloth, as shall be afterwards explained. Three crown wheels G, of which one is shown in the section, *fig.* 1214, are, as usual, keyed by a wedge to the shaft F. Their contour is a sinuous

1214



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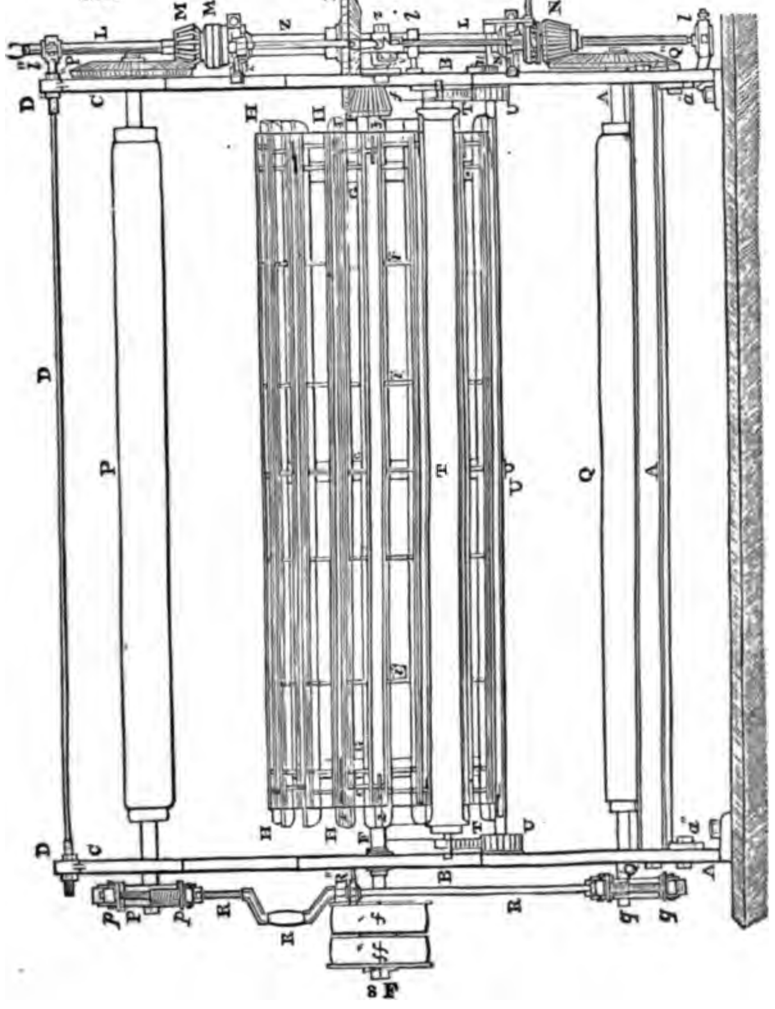
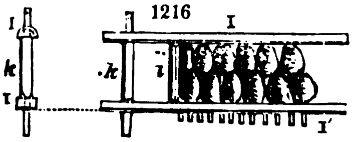


band, with six semi-cylindrical hollows, separated alternately by as many portions of the periphery. One of these three wheels is placed in the middle of the shaft F, and the other two, towards its extremities. Their size may be judged of, from inspection of *fig.* 1214. After having set them so that all their spokes or radii correspond exactly, the 16 sides H, are made fast to the 16 portions of the periphery, which correspond in the three wheels. These sides are made of sheet iron, curved into a gutter form, *fig.* 1214, but rounded off at the end, *fig.* 1215, and each of them is fixed to the three felloes of the wheels by three bolts *h*. The elastic part of the plate iron allows of their being sufficiently well adjusted, so that their flat portions furthest from the centre may lie pretty truly on a cylindrical surface, whose axis would coincide with that of the shaft F.

Between the 16 sides there are 16 intervals, which correspond to the 16 hollowings of each of the wheels. Into these intervals are adjusted, with proper precaution, 16 frames bearing the teasels which are to act upon the cloth. These are fitted in as follows:—Each has the shape of a rectangle, of a length equal to that of the drum, but their breadth only large enough to contain two thistle-heads set end to end, thus making two rows of parallel teasels throughout the entire length, (see the contour in *fig.* 1214.) A portion of the frame is represented in *fig.* 1216. The large side I, against which the tops of the teasels rest, is hollowed out into a semi-cylinder, and its opposite side is cleft throughout its whole length, to receive the tails of the teasels, which are seated and compressed in it. There are, moreover, cross-bars *i*, which serve to maintain the sides of the frame I, at an invariable distance, and to form short compartments for keeping the thistles compact. The ends are fortified by stronger bars *k*, *k*, with projecting bolts to fasten the frames between the ribs. The distance of the sides of the frame I, I′, ought to be such, that if a frame be laid upon the drum, in the interval of two ribs, the side I will rest upon the inclined plane of one of the ribs, and the side I′ upon the inclined plane of the other (see *fig.* 1214); while at the same time the bars *k*, of the two ends of the frame, rest upon the flat parts of the ribs themselves. This point being secured, it is obvious, that if the ends of the bars *k* be stopped, the frame will be made fast. But they need not be fixed in a permanent manner, because they must be frequently removed and replaced. They are fastened by the clamp (*figs.* 1217, 1218), which is shut at the one end, and furnished at the other with a spring, which can be opened or shut at pleasure. 2 and 4, in *fig.* 1215 (near the right end of the shaft F), shows the place of the clamp, *figs.* 1217, 1218. The bar of the right hand is first set in the clamp, by holding up its other end; the frame is then let down into the left-hand clamp.

1216



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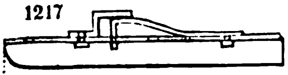
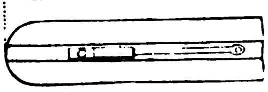


1218



The cloth is wound upon the lower beam Q, *fig.* 1214; thence it passes in contact with a wooden cylinder T, turning upon an axis, and proceeds to the upper beam P, on to which it is wound: by a contrary movement, the cloth returns from the beam P to Q, over the cylinder T; and may thus go from the one to the other as many times as shall be requisite. In these successive circuits it is presented to the action of the teasels, under certain conditions. In order to be properly teasled, it must have an equal tension throughout its whole breadth during its traverse; it must be brought into more or less close contact with the drum, according to the nature of the cloth, and the stage of the operations; sometimes being a tangent to the surface, and sometimes embracing a greater or smaller portion of its contour, it must travel with a determinate speed, dependant upon the velocity of the drum, and calculated so as to produce the best result: the machine itself must make the stuff pass alternately from one winding beam to the other.

In *fig.* 1215, before the front end of the machine, there is a vertical shaft L, as high as the framework, which revolves with great facility, in the bottom step *l*, the middle collet *l′*, and top collet *l″*, in the prolongation of the stretcher D. Upon this upright shaft are mounted—1. a bevel wheel L′; 2. an upper bevel pinion M, with its boss M′; 3. a lower bevel pinion N, with its boss N′. The bevel wheel L′ is keyed upon the shaft L, and communicates to it the movement of rotation which it receives from the pinion *f*, with which it is in gear; but the pinion *f*, which is mounted upon the shaft F of the drum, participates in the rotation which this shaft receives from the prime mover, by means of the fast rigger-pulley *f′*. The upper pinion M is independent upon the shaft L; that is to say, it may be slidden along it, up and down, without being driven by it; but it may be turned in an indirect manner by means of six curved teeth, projecting from its bottom, and which may be rendered active or not, at pleasure; these curved teeth, and their intervals, correspond to similar teeth and intervals upon the top of the boss M′, which is dependent, by feathered indentations, upon the rotation of L, though it can slide freely up and down upon it. When it is raised, therefore, it comes into gear with M. The pinion N, and its boss, have a similar mode of being thrown into and out of gear with each other. The bosses M′ and N′, ought always to be moved simultaneously, in order to throw one of them into gear, and the other out of gear. The shaft L serves to put the cloth in motion, by means of the bevel wheels P″ and Q″, upon the ends of the beams P, Q, which take into the pinions M and N.

The mechanism destined to stretch the cloth is placed at the other end of the machine, where the shafts of the beams P, Q, are prolonged beyond the frame, and bear at their extremities P′ and Q′, armed each with a brake. The beam P (*fig.* 1214), turns in an opposite direction to the drum; consequently the cloth is wound upon P, and unwound from Q. If, at the same time as this is going on, the handle R′, of the brake-shaft, be turned so as to clasp the brake of the pulley Q′, and release that of the pulley P′, it is obvious that a greater or smaller resistance will be occasioned in the beam Q, and the cloth which pulls it in unwinding, will be able to make it turn only when it has acquired the requisite tension; hence it will be necessary, in order to increase or diminish the tension, to turn the handle R′ a little more or a little less in the direction which clasps the brake of the pulley Q′; and as the brake acts in a very equable manner, a very equable tension will take place all the time that the cloth takes to pass. Besides, should the diminution of the diameter of the beam Q, render the tension less efficacious in any considerable degree, the brake would need to be unclamped a very little, to restore the primitive tension.

When the cloth is to be returned from the beam P, to the beam Q, Z must be lowered, to put the shaft L out of gear above, and in gear below; then the cloth-beam Q, being driven by that vertical shaft, it will turn in the same direction as the drum, and will wind the cloth round its surface. In order that it may do so, with a suitable tension, the pulley Q′ must be left free, by clasping the brake of the pulley P′, so as to oppose an adequate resistance.

The cloth is brought into more or less close contact with the drum as follows:—There is for this purpose a wooden roller T, against which it presses in passing from the one winding beam to the other, and which may have its position changed relatively to the drum. It is obvious, for example, that in departing from the position represented in *fig.* 1214, where the cloth is nearly a tangent to the drum, if the roller T′ be raised, the cloth will cease to touch it; and if it be lowered, the cloth will, on the contrary, embrace the drum over a greater or less portion of its periphery. For it to produce these effects, the roller is borne at each end, by iron gudgeons, upon the heads of an arched rack T″ (*fig.* 1214), where it is held merely by pins. These racks have the same curvature as the circle of the frame, against which they are adjusted by two bolts; and by means of slits, which these bolts traverse, they may be slidden upwards or downwards, and consequently raise or depress the roller T. But to graduate the movements, and to render them equal in the two racks, there is a shaft U, supported by the uprights of the frame, and which carries, at each end, pinions U′, U″, which work into the two racks T′, T″; this shaft is extended in front of the frame, upon the side of the head of the machine (*fig.* 1215), and there it carries a ratchet wheel *u*, and a handle *u*′. The workman, therefore, requires merely to lay hold of the handle, and turn it in the direction of the ratchet wheel, to raise the racks, and the roller T, which they carry; or to lift the click or catch, and turn the handle in the opposite direction, when he wishes to lower the roller, so as to apply the cloth to a larger portion of the drum.

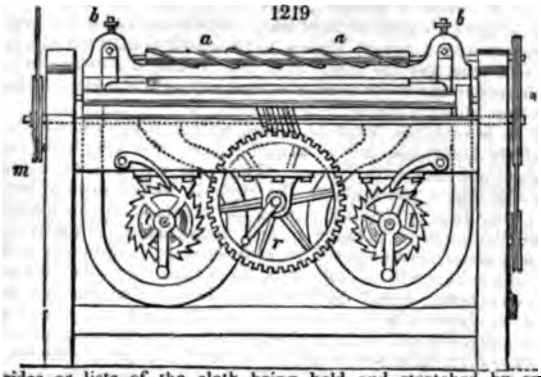
CLOTH CROPPING.

Of machines for cropping or shearing woollen cloths, those of Lewis and Davis have been very generally used.

Fig. 1219 is an end view, and *fig.* 1220 is a side view, of Lewis's machine for shearing cloth from list to list. *Fig.* 1221 is an end view of the carriage, with the rotatory cutter detached from the frame of the machine, and upon a larger scale; *a*, is a cylinder of metal, on which is fixed a triangular steel wire; this wire is previously bent round the cylinder in the form of a screw, as represented at *a*, *a*, in *fig.* 1219, and, being hardened, is intended to constitute one edge of the shear or cutter.

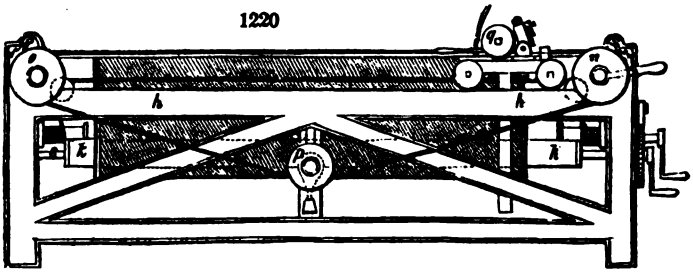
The axis of the cylindrical cutter *a*, turns in the frame *b*, which, having proper adjustments, is mounted upon pivots *c*, in the standard of the travelling carriage *d*, *d*; and *e*, is the fixed or ledger blade, attached to a bar *f*, which constitutes the other edge of the cutter; that is, the stationary blade, against which the edges of the rotatory cutter act; *f* and *g*, are flat springs, intended to keep the cloth (shown by dots) up against the cutting edges. The form of these flat springs *f*, *g*, is shown at *figs.* 1222 and 1223, as consisting of plates of thin metal cut into narrow slips (*fig.* 1222), or perforated with long holes, (*fig.* 1223.) Their object is to support the cloth, which is intended to pass between them, and operate as a spring bed, bearing the surface of the cloth against the cutters, so that its pile or nap may be cropped off or shorn as the carriage *d* is drawn along the top rails of the standard or frame of the machine *h*, *h*, by means of cords.

1219

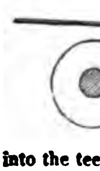


The piece of cloth to be shorn, is wound upon the beam *k*, and its end is then conducted through the machine, between the flat springs *f* and *g* (as shown in *fig.* 1221), to the other beam *l*, and is then made fast; the sides or lists of the cloth being held and stretched by small hooks, called habiting hooks. The cloth being thus placed in the machine, and drawn tight, is held distended by means of ratchets on the ends of the beams *k* and *l*, and palls. In commencing the operation of shearing, the carriage *d*, must be brought back, as in *fig.* 1221, so that the cutters shall be close to the list; the frame of the cutters is raised up on its pivots as it recedes, in order to keep the cloth from injury, but is lowered again previously to being put in action. A band or winch is applied to the rigger or pulley *m*, which, by means of an endless cord passed round the pulley *n*, at the reverse end of the axle of *m*, and round the other pulleys *o* and *p*, and the small pulley *q*, on the axle of the cylindrical cutter, gives the cylindrical cutter a very rapid rotatory motion; at the same time a worm, or endless screw, on the axle of *m* and *n*, taking into the teeth of the large wheel *r*, causes that wheel to revolve, and a small drum *s*, upon its axle, to coil up the cord, by which the carriage *d*, with the cutters *a* and *e*, and the spring bed *f* and *g*, are slowly, but progressively, made to advance, and to carry the cutters over the face of the cloth, from list to list; the rapid rotation of the cutting cylinder *a*, producing the operation of cropping or shearing the pile.

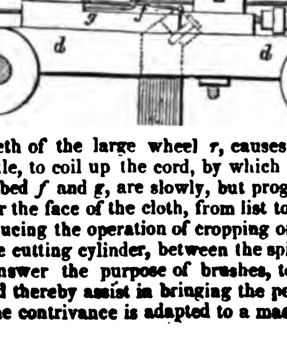
1220



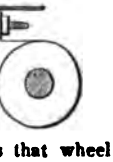
1222



1221



1233

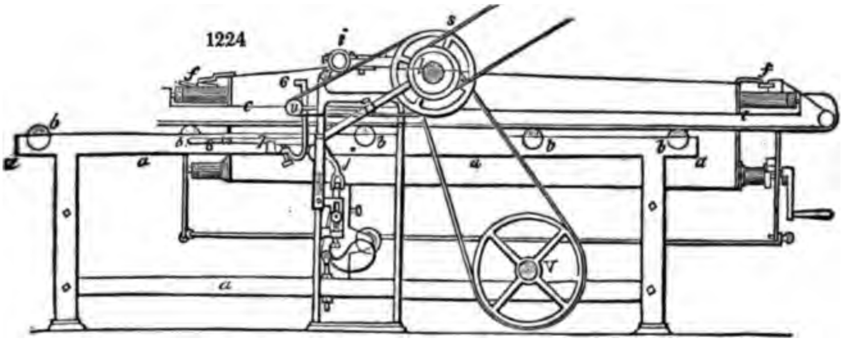


Upon the cutting cylinder, between the spiral blades, it is proposed to place stripes of plush, to answer the purpose of brushes, to raise the nap or pile as the cylinder goes round, and thereby assist in bringing the points of the wool up to the cutters.

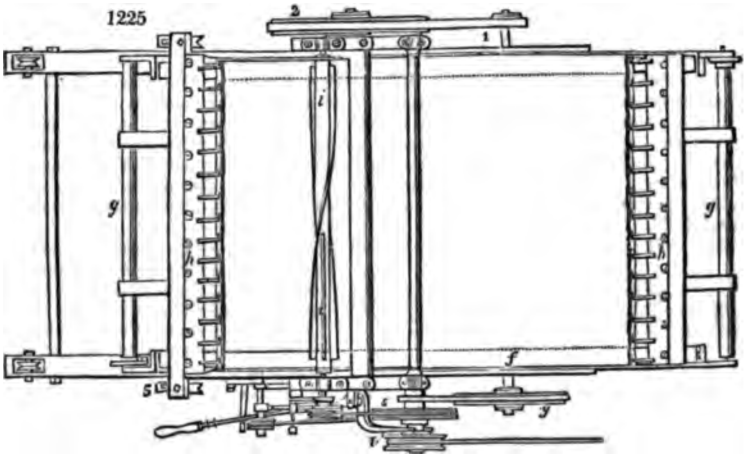
The same contrivance is adapted to a machine for shearing the cloth lengthwise.

Fig. 1224, is a geometrical elevation of one side of Mr. Davis's machine. *Fig.* 1225, a plan or horizontal representation of the same, as seen in the top; and *fig.* 1226, a section taken vertically across the machine near the middle, for the purpose of displaying the working parts more perfectly than in the two preceding figures. These three figures represent a complete machine in working condition, the cutters being worked by a rotatory motion, and the cloth so placed in the carriage as to be cut from list to list. *a*, *a*, *a*, is a frame or standard, of wood or iron, firmly bolted together by cross braces at the ends and in the middle. In the upper side-rails of the standard, there is a series of axles carrying anti-friction wheels *b*, *b*, *b*, upon which the side-rails *c*, *c*, of the carriage or frame that bears the cloth runs, when it is passing under the cutters in the operation of shearing. The side-rails *c*, *c*, are straight bars of iron, formed with edges *v*, on their under sides, which run smoothly in the grooves of the rollers *b*, *b*, *b*. These side-rails are firmly held together by the end stretchers *d*, *d*. The sliding frame has attached to it the two lower rollers *e*, *e*, upon which the cloth intended to be shorn is wound; the two upper lateral rollers *f*, *f*, over which the cloth is conducted and held up; and the two end rollers *g*, *g*, by which the habiting rails *h*, *h*, are drawn tight.

1224



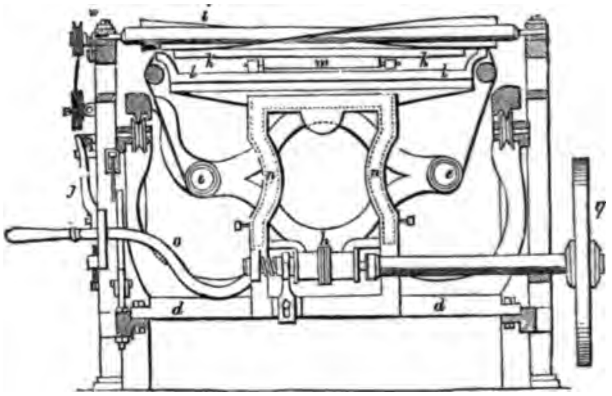
1225



In preparing to shear a piece of cloth, the whole length of the piece is, in the first place, tightly rolled upon one of the lower rollers *e*, which must be something longer than the breadth of the cloth from list to list. The end of the piece is then raised, and passed over the top of the lateral rollers *f*, *f*, whence it is carried down to the other roller *e*, and its end or farral is made fast to that roller. The hooks of the habiting rails *h*, *h*, are then put into the lists, and the two lower rollers *e*, *e*, with the two end rollers *g*, *g*, are then turned, for the purpose of drawing up the cloth, and straining it tight, which tension is preserved by ratchet wheels attached to the ends of the respective rollers, with palls dropping into their teeth. The frame carrying the cloth is now slidden along upon the top standard rails by hand, so that the list shall be brought nearly up to the cutter *i*, *i*, ready to commence the shearing operation; the bed is then raised, which brings the cloth up against the edges of the shears.

The construction of the bed will be seen by reference to the cross section, *fig.* 1226. It consists of an iron or other metal roller *k*, *k*, turned to a truly cylindrical figure, and covered with cloth or leather, to afford a small degree of elasticity. This roller is mounted upon pivots in a frame *l*, *l*, and is supported by a smaller roller *m*, similarly mounted, which roller *m*, is intended merely to prevent any bending or depression of the central part of the upper roller or bed *k*, *k*, so that the cloth may be kept in close contact with the whole length of the cutting blades.

1226

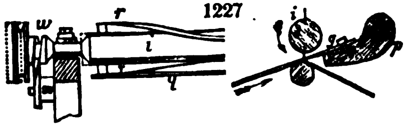


In order to allow the bed *k* to rise and fall, for the purpose of bringing the cloth up to the cutters to be shorn, or lowering it away from them after the operation, the frame *l*, *l*, is made to slide up and down in the grooved standard *n*, *n*, the moveable part enclosed within the standard being shown by dots. This standard *n*, is situated about the middle of the machine, crossing it immediately under the cutters, and is made fast to the frame *a*, by bolts and screws. There is a lever *o*, attached to the lower cross-rail of the standard, which turns upon a fulcrum-pin, the extremity of the shorter arm of which lever acts under the centre of the sliding-frame, so that by the lever *o*, the sliding-frame, with the bed, may be raised or lowered, and when so raised, be held up by a spring catch *j*.

It being now explained by what means the bed which supports the cloth is constructed, and brought up, so as to keep the cloth in close contact with the cutters, while the operation of shearing is going on; it is necessary in the next place to describe the construction of the cutters, and their mode of working; for which purpose, in addition to what is shown in the first three figures, the cutters are also represented detached, and upon a larger scale, in *fig.* 1227.

In this figure is exhibited a portion of the cutters in the same situation as in *fig.* 1221; and alongside of it is a section of the same, taken through it at right angles to the former; *p*, is a metallic bar or rib, somewhat of a wedge form, which is fastened to the top part of the standard *a*, *a*, seen best in *fig.* 1220. To this bar a straight blade of steel *g*, is attached by screws, the edge of which stands forward even with the centre or axis of the cylindrical cutter *i*, and forms the ledger blade, or lower fixed edge of the shears. This blade remains stationary, and is in close contact with the pile or nap of the cloth, when the bed *k* is raised, in the manner above described.

1227



The cutter or upper blade of the shears is formed by inserting two or more strips of plate steel *r*, *r*, in twisted directions, into grooves in the metallic cylinder *i*, *i*, the edges of which blades *r*, as the cylinder *i* revolves, traverse along the edge of the fixed or ledger blade *g*, and by their obliquity produce a cutting action like shears; the edges of the two blades taking hold of the pile or raised nap, as the cloth passes under it, shaves off the superfluous ends of the wool, and leaves the face smooth.

Rotatory motion is given to the cutting cylinder *i*, by means of a band leading from the wheel *s*, which passes round the pulley fixed on the end of the cylinder *i*, the wheel *s* being driven by a band leading from the rotatory part of a steam-engine, or any other first mover, and passed round the rigger *t*, fixed on the axle *s*. Tension is given to this band by a tightening pulley *u*, mounted on an adjustable sliding-piece *v*, which is secured to the standard by a screw; and this rigger is thrown in and out of gear by a clutch-box and lever, which sets the machine going, or stops it.

In order to give a drawing stroke to the cutter, which will cause the piece of cloth to be shorn off with better effect, the upper cutter has a slight lateral action, produced by the axle of the cutting cylinder being made sufficiently long to allow of its sliding laterally about an inch in its bearings; which sliding is effected by a cam *w*, fixed at one end. This cam is formed by an oblique groove, cut round the axle (see *w*, *fig.* 1227), and a tooth *x*, fixed to the frame or standard which works in it, as the cylinder revolves. By means of this tooth, the cylinder is made to slide laterally, a distance equal to the obliquity of the groove *w*, which produces the drawing stroke of the upper shear. In order that the rotation of the shearing cylinder may not be obstructed by friction, the tooth *x*, is made of two pieces, set a little apart, so as to afford a small degree of elasticity.

The manner of passing the cloth progressively under the cutters is as follows:—On the axle of the wheel *s*, and immediately behind that wheel, there is a small rigger, from which a band passes to a wheel *y*, mounted in an axle turning in bearings on the lower side-rail of the standard *a*. At the reverse extremity of this axle, there is another small rigger 1, from which a band passes to a wheel 2, fixed on the axle 3, which crosses near the middle of the machine, seen in *fig.* 1226. Upon this axle there is a sliding pulley 4, round which a cord is passed several times, whose extremities are made fast to the ends of the sliding carriage *d*; when, therefore, this pulley is locked to the axle, which is done by a clutch box, the previously described movements of the machine cause the pulley 4 to revolve, and by means of the rope passed round it, to draw the frame, with the cloth, slowly and progressively along under the cutters.

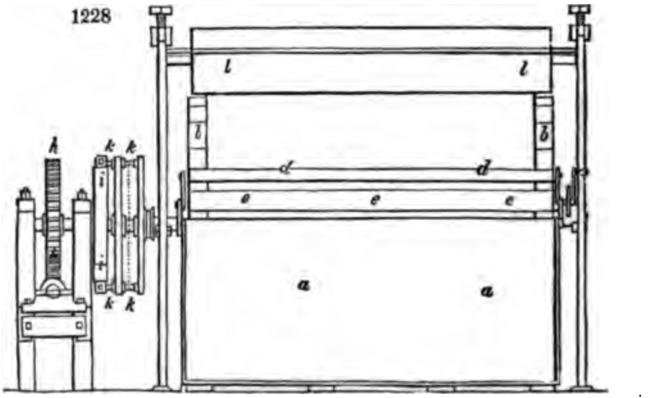
It remains only to point out the contrivance whereby the machinery throws itself out of gear, and stops its operations, when the edge of the cloth or list arrives at the cutters.

At the end of one of the habiting rails *h*, there is a stop affixed by a nut and screw 5, which, by the advance of the carriage, is brought up and made to press against a lever 6; when an arm from this lever 6, acting under the catch 7, raises the catch up, and allows the hand-lever 8, which is pressed upon by a strong spring, to throw the clutch-box 10, out of gear with the wheel 8; whereby the evolution of the machine instantly ceases. The lower part of the lever 6, being connected by a joint to the top of the lever *j*, the receding of the lever 6, draws back the lower catch *j*, and allows the sliding frame *l*, *l*, within the bed *k*, to descend. By now turning the lower rollers *e*, *e*, another portion of the cloth is brought up to be shorn; and when it is properly habited and strained, by the means above described, the carriage is slidden back, and, the parts being all thrown into gear, the operation goes on as before.

Mr. Hirst's improvements in manufacturing woollen cloths, for which a patent was obtained in February, 1830, apply to that part of the process where a permanent lustre is given usually by what is called roll-boiling; that is, stewing the cloth, when tightly wound upon a roller, in a vessel of hot water or steam. As there are many disadvantages attendant upon the operation of roll-boiling, such as injuring the cloths, by overheating them, which weakens the fibre of the wool, and also changes some colors, he substituted, in place of it, a particular mode of acting upon the cloths, by occasional or intermitted immersion in hot water, and also in cold water, which operations may be performed either with or without pressure upon the cloth, as circumstances may require.

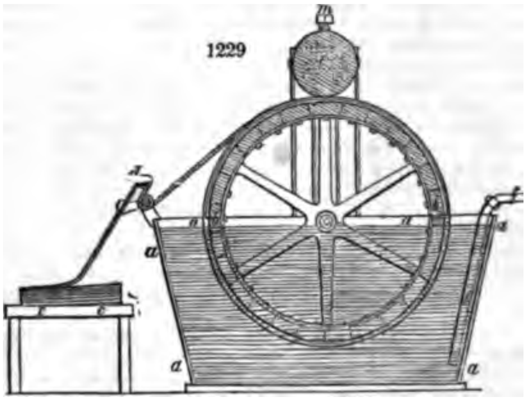
The apparatus which he proposes to employ for carrying on his improved process, is shown in the accompanying drawing. *Fig.* 1228, is a front view of the apparatus, complete, and in working order; *fig.* 1229, is a section, taken transversely through the middle of the machine, in the direction of *fig.* 1230; and *fig.* 1230, is an end view of the same; *a*, *a*, *a*, is a vessel or tank, made of iron or wood, or any other suitable material; sloping at the back and front, and perpendicular at the ends. This tank must be suffi-

1228



ciently large to admit of half the diameter of the cylinder or drum *b*, *b*, *b*, being immersed into it, which drum is about four feet diameter, and about six feet long, or something more than the width of the piece of cloth intended to be operated upon. This cylinder or drum *b*, *b*, is constructed by combining segments of wood cut radially on their edges, secured by screw-bolts to the rims of the iron wheels, having arms, with an axle passing through the middle.

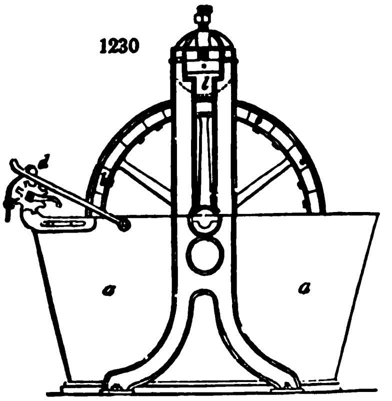
1229



The cylinder or drum being thus formed, rendered smooth on its periphery, and mounted upon its axle in the tank, the piece of cloth is wound upon it as tightly as possible, which is done by placing it in a heap upon a stool, as at *c*, *fig.* 1229, passing its end over and between the tension-rollers *d*, *e*, and then securing it to the drum, the cloth is progressively drawn from the heap, between the tension-rollers, which are confined by a pall and ratchet, on to the periphery of the drum, by causing the drum to revolve upon its axis, until the whole piece of cloth is tightly wound upon the drum; it is then bound round with canvass or other wrappers, to keep it secure.

If the tank has not been previously charged with clean and pure water, it is now filled to the brim, as shown at *fig.* 1229, and opening the stop-cock of the pipe *f*, which leads from a boiler, the steam is allowed to blow through the pipe, and discharge itself at the lower end, by which means the temperature of the water is raised in the tank to about 170° Fahr. Before the temperature of the water has got up, the drum is set in slow rotatory motion, in order that the cloth may be uniformly heated throughout; the drum making about one rotation per minute. The cloth, by immersion in the hot water, and passing through the cold air, in succession, for the space of about eight hours, gets a smooth soft face, the texture not being rendered harsh, or otherwise injured, as is frequently the case by roll-boiling.

1230



Uniform rotatory motion to the drum is shown in *fig.* 1228, in which *g* is an endless screw or worm, placed horizontally, and driven by a steam-engine or any other first mover employed in the factory. This endless screw takes into the teeth of, and drives, the vertical wheel *h*, upon the axle of which the coupling-box *i*, *i*, is fixed, and, consequently, continually revolves with it. At the end of the shaft of the drum, a pair of sliding clutches *k*, *k*, are mounted, which, when projected forward, as shown by dots in *fig.* 1228, produce the coupling or locking of the drum-shaft to the driving wheel, by which the drum is put in motion; but on withdrawing the clutches *k*, *k*, from the coupling-box *i*, *i*, as in the figure, the drum immediately stands still.

After operating upon the cloth in the way described, by passing it through hot water for the space of time required, the hot water is to be withdrawn by a cock at the bottom, or otherwise, and cold water introduced into the tank in its stead; in which cold water the cloth is to be continued turning, in the manner above described, for the space of twenty-four hours, which will perfectly fix the lustre that the face of the cloth has acquired by its immersion in the hot water, and leave the pile or nap, to the touch, in a soft silky state.

In the cold-water operation he sometimes employs a heavy pressing roller *l*, which, being mounted in slots in the frame or standard, revolves with the large drum, rolling over the back of the cloth as it goes round. This roller may be made to act upon the cloth with any required pressure, by depressing the screws *m*, *m*, or by the employment of weighted levers, if that should be thought necessary.

Pressing is the last finish of cloth to give it a smooth level surface. The piece is folded backwards and forwards in yard lengths, so as to form a thick package on the board of a screw or hydraulic press. Between every fold sheets of glazed paper are placed to prevent the contiguous surfaces of cloth from coming into contact; and at the end of every twenty yards, three hot iron plates are inserted between the folds, the plates being laid side by side, so as to occupy the whole surface of the folds. Thin sheets of iron not heated are also inserted above and below the hot plates to moderate the heat. When the packs of cloth are properly folded, and piled in sufficient number in the press, they are subjected to a severe compression, and left under its influence till the plates get cold. The cloth is now taken out and folded again, so that the creases of the former folds may come opposite to the flat faces of the paper, and be removed by a second pressure. In finishing superfine cloths, however, a very slight pressure is given with iron plates but moderately warmed. The satiny lustre and smoothness given by strong compression with much heat is objectionable, as it renders the surface apt to be come spotted and disfigured by rain.

WOOTZ, is the Indian name of steel.

WORT, is the fermentable infusion of malt or grains. See Beer.

WOULFE'S APPARATUS, is a series of vessels, connected by tubes, for the purpose of condensing gaseous products in water. See Acetic Acid, *fig.* 1; also Muriatic Acid.

X.

XANTHINE, is the name given by Kuhlmann to the yellow dyeing-matter contained in madder.

Y.

YEAST, is the froth of fermenting worts. See Beer and Fermentation.

YELLOW DYE. (*Teinture jaune*, Fr.; *Gelbfärben*, Germ.) *Annotto*, *dyer's-broom*, (*Genista tinctoria*,) *fustic*, *fustet*, *Persian or French berries*, *quercitron bark*, *saw-wort*, (*Serratula tinctoria*,) *turmeric*, *weld*, and *willow leaves*, are the principal yellow dyes of the vegetable kingdom; *chromate of lead*, *iron-oxyde*, *nitric acid*, (for silk,) *sulphuret of antimony*, and *sulphuret of arsenic*, are those of the mineral kingdom. Under these articles, as also under Calico-printing, Dyeing, and Mordants, ample instructions will be found for communicating this color to textile and other fibrous substances. Alumina and oxyde of tin are the most approved bases of the above vegetable dyes. A nankin dye may be given with *bablah*, especially to cotton oiled preparatory to the Turkey red process. See Madder.

YELLOW, KING'S, is a poisonous yellow pigment. See Arsenic and Orpiment.

YTTRIA, is a rare earth, extracted from the minerals gadolinite and yttrotantalite, being an oxyde of the metal yttrium.

Z.

ZAFFRE. See Cobalt.

ZEDOARY, is the root of a plant which grows in Malabar, Ceylon, &c. It occurs in wrinkled pieces, externally ash-colored, internally brownish-red; possessed of a fragrant odor, somewhat resembling camphor; and of a pungent, aromatic, bitterish taste. It contains, according to Bucholz, 1·42 of volatile oil, of a burning camphorated taste; 3·60 of a soft, bitter, aromatic resin; 11·75 of a bitter aromatic extract, mixed with a little resin and potash-salts; 4·5 of gum; 9 of vegetable mucilage; 3·60 of starch; 8·0 of a starchy extract from the woody fibre, by means of caustic potassa, along with 31·2 of another matter, 12·89 of woody fibre, and 15 of water. According to Moria, this root contains, besides, an azotized substance, analogous to the extract of beef.

ZIMOME, is a principle supposed by Taddei to exist in the gluten of wheat-flour. Its identity is not recognised by later chemists.

ZIRCON. See Hyacinth and Lapidary.

ZIRCONIA, is a rare earth, extracted from the minerals zircon and hyacinth; it is an oxyde of zirconium, a substance possessing externally none of the metallic characters, but resembling rather charcoal powder, which burns briskly, and almost with explosive violence.

ZINC, is a metal of a bluish-white color, of considerable lustre when broken across, but easily tarnished by the air; its fracture is hackly, and foliated with small facets, irregularly set. It has little cohesion, and breaks in thin plates before the hammer, unless it has been previously subjected to a regulated process of lamination, at the temperature of from 220° to 300° F., whereby it becomes malleable, and retains its malleability and ductility afterwards. On this singular property, a patent was taken out by Messrs. Hobson and Sylvester, of Sheffield, many years ago, for manufacturing sheet zinc, for covering the roofs of houses, and sheathing ships; but the low price of copper at that time, and its superior tenacity, rendered their patent ineffective. The specific gravity of zinc varies from 6·9 to 7·2, according to the condensation it has received. It melts under a red heat, at about the 680th or 700th degree of Fahrenheit's scale. When exposed to this heat with contact of air, the metal takes fire, and burns with a brilliant bluish-white light, while a few flocculi, of a woolly-looking white matter, rise out of the crucible, and float in the air. The result of the combustion is a white powder, formerly called flowers, but now oxyde of zinc; consisting of 34 of metal, and 8 of oxygen, being their respective prime equivalents; or, in 100 parts, of 81 and 19.

The principal ores of zinc are, the sulphuret called *blende*, the silicate called *calamine*, and the sparry calamine, or the carbonate.

1. *Blende* crystallizes in the garnet-dodecahedron; its fracture is highly conchoidal; lustre, adamantine; colors, black, brown, red, yellow, and green; transparent or translucent; specific gravity, 4. It is a simple sulphuret of the metal; and, therefore, consists, in its pure state, of 34 of zinc, and 16 of sulphur. It dissolves in nitric acid, with disengagement of sulphureted hydrogen gas. It occurs in beds and veins, accompanied chiefly by galena, iron pyrites, copper pyrites, and heavy spar. There is a radiated variety found at Przibram, remarkable for containing a large proportion of cadmium. Blende is found in great quantities in Derbyshire and Cumberland, as also in Cornwall.

2. *Calamine*, or silicate of zinc, is divided into two species; the prismatic or electric calamine, and the rhomboidal; though they both agree in metallurgic treatment. The *first* has a vitreous lustre, inclining to pearly; color, white, but occasionally blue, green, yellow, or brown; spec. grav. 3·38. It often occurs massive, and in botroidal shapes. This species is a compound of oxyde of zinc with silica and water; and its constituents are—zinc oxyde, 66·37; silica, 26·23; water, 7·4; in 100 parts. Reduced to powder, it is soluble in dilute sulphuric or nitric acid, and the solution gelatinizes on cooling. It emits a green phosphorescent light before the blowpipe. The second species, or rhombohedral calamine, is a carbonate of zinc. Its specific gravity is 4·442, much denser than the preceding. It occurs in kidney-shaped, botroidal, stalactitic, and other imitative shapes; surface generally rough, composition columnar. Massive, with a granular texture, sometimes impalpable; strongly coherent. According to Smithson's analysis, Derbyshire calamine consists of—oxyde of zinc, 65·2; carbonic acid, 34·8; which coincides almost exactly with a prime equivalent of the oxyde and acid, or 42 + 22 = 64.

The mineral genus called *zinc-ore*, or red oxyde of zinc, is denser than either of the above, its spec. grav. being 5·432. It is a compound of oxyde of zinc 88, and oxyde of iron and manganese 12. It is found massive, of a granular texture, in large quantities, in several localities, in New Jersey. It is set free in several metallurgic processes, and occurs crystallized in six-sided prisms of a yellow color, in the smelting-works of Kœnigshutte in Silesia, according to Mitscherlich.

The zinc ores of England, like those of France, Flanders, and Silesia, occur in two geological localities.

The first is in veins in the carboniferous or mountain limestone. The blende and the calamine most usually accompany the numerous veins of galena which traverse that limestone; though there are many lead mines that yield no calamine; and, on the other hand, there are veins of calamine alone, as at Matlock, whence a very considerable quantity of this ore is obtained.

In almost every point of England where that metalliferous limestone appears, there are explorations for lead and zinc ores. The neighborhood of Alston-moor in Cumberland, of Castleton and Matlock in Derbyshire, and the small metalliferous belt of Flintshire, are peculiarly marked for their mineral riches. On the north side of the last county, calamine is mined in a rich vein of galena at Holywell, where it presents the singular appearance of occurring only in the ramifications that the lead vein makes from east to west, and never in those from north to south; while the blende, abundantly present in this mine, is found indifferently in all directions.

The second locality of calamine is in the magnesian limestone formation of the English geologists, the alpine limestone of the French, and the zechstein of the Germans. The calamine is disseminated through it in small contemporaneous veins, which, running in all directions, form the appearance of network. These veins have commonly a thickness of only a few inches; but in certain cases they extend to four feet, in consequence of the union of several small ones into a mass. The explorations of calamine in the magnesian limestone, are situated chiefly on the flanks of the Mendip Hills, a chain which extends in a northwest and southeast direction, from the canal of Bristol to Frome. The calamine is worked mostly in the parishes of Phipham and Roborough, as also near Rickford and Broadfield-Doron, by means of a great multitude of small shafts. The miners pay, for the privilege of working, a tax of 1*l.* sterling per annum to the Lords of the Treasury; and they sell the ores, mixed with a considerable quantity of carbonate of lime, for 1*l.* per ton, at Phipham, after washing it slightly in a sieve. They are despatched to Bristol, where they receive a new washing, in order to separate the galena.

OF THE SMELTING OF THE ORES OF ZINC.

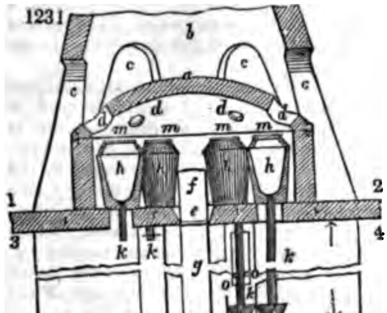
The greater part of the zinc works are situated in the neighborhood of Birmingham and Bristol. The manufacture of brass, which has been long one of the staple articles of these towns, was probably the cause of the introduction of this branch of industry, at the period when brass began to be made by the direct union of copper with metallic zinc, instead of calamine. A few zinc furnaces exist also in the neighborhood of Sheffield, amid the coal-pits surrounding that town. Bristol and Birmingham derive their chief supply of ores from the Mendip Hills and Flintshire; and Sheffield, from Alston-moor.

The calamine, freed from the galena by sorting with the hand, is calcined before its introduction into the smelting-furnaces, by being exposed, coarsely bruised, in reverberatory ovens, 10 feet long, and 8 broad, in a layer 6 inches thick. In some establishments the calcination is omitted, and the calamine, broken into pieces about the size of a pigeon's egg, is mixed with its bulk of small coal.

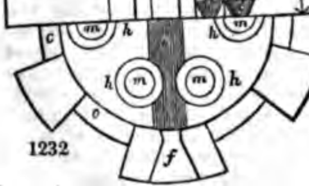
Zinc is smelted in England, likewise from blende, (sulphuret of zinc.) This ore, after being washed, and broken into pieces of the size of a filbert, was sold a few years ago at the mine of Holywell for 3*l.* a ton, or half the price of calamine. It is roasted, without any other preparation, in reverberatory furnaces; which are about 8 feet wide, and 10 long; the distance between the roof and the sole being 30 inches, and the height of the fire-bridge, 18. The layer of blende, which is placed on the hearth, is about 4 or 5 inches thick; and it is continually stirred up with rakes. One ton of it requires, for roasting, four tons of coals; and it suffers a loss of 20 per cent. The operation takes from 10 to 12 hours. The mixture of reducing consists of one fourth part of the desulphureted oxyde, one fourth of calcined calamine, and one half part of charcoal; which affords commonly 30 per cent. of zinc.

The English furnaces for smelting zinc ores are sometimes quadrangular, sometimes round; the latter form being preferable. They are mounted with from 6 to 8 crucibles or pots (see *fig.* 1231), arched over with a cupola *a*, placed under a conical chimney *b*, which serves to give a strong draught, and to carry off the smoke. In this cone there are as many doors *c*, *c*, *c*, as there are pots in the furnace; and an equal number of vents *d*, *d*, *d*, in the cupola, through which the smoke may escape, and the pots may be set. In the surrounding walls there are holes for taking out the pots, when they become unserviceable; after the pots are set, these holes are bricked up. The pots are heated to ignition in a reverberatory furnace before being set, and are put in by means of iron tong machinery supported upon two wheels, as is the case with glass-house pots. *e*, is the grate; *f*, the door for the fuel; *g*, the ash-pit. The pots *h*, *h*, *h*, have a hole in the centre of their bottom, which is closed with a wooden plug, when they are set charged with calamine, mixed with one seventh of coal; which coal prevents the mixture from falling through the orifice, when the heat rises and consumes the plug. The sole of the hearth *i*, *i*, upon which the crucibles stand, is perforated under each of them, so that they can be reached from below; to the bottom orifice of the pot, when the distillation begins, a long sheet-iron pipe *k*, is joined, which dips at its end into a water vessel *l*, for receiving in drops the condensed vapors of the zinc. The pot

1231



1232



is charged from above, through an orifice in the lid of the pot, which is left open after the firing, till the bluish color of the flame shows the volatilization of the metal; immediately whereupon the hole is covered with a fire-tile *m*. The iron tubes are apt to get obstructed during the distillation, and must therefore be occasionally cleared out with a redhot rod. When the distillation is finished, the iron pipes must be removed; the coaly and other contents of the pot cleared away. A pot lasts about four months upon an average. Five distillations may be made in the course of 14 days, in which from 6 to 10 tons of calamine may be worked up, and from 22 to 24 tons of coals consumed, with a product of two tons of zinc. The metal amounts to from 25 to 40 per cent. of the ore.

1, 2, is the level of the upper floor; 3, 4, level of the lower ceiling of the lower floor. *Fig.* 1232, ground plan on the level of 1, 2; only one half is here shown.

The zinc collected in this operation is in the form of drops, and a very fine powder, mingled with some oxyde. It must be melted in an iron pot or boiler, set in a proper furnace; and the oxyde is skimmed off the surface, to be returned into the crucibles. The metal is, lastly, cast into square bars or ingots.

The crucibles are discharged at the end of each operation, by withdrawing the condenser, breaking with a rake the piece of charcoal which shuts their bottom, and then emptying them completely, by shaking their upper part. In replacing the condenser-pipe *k* (see second pot from the right hand, *fig.* 1230), the flange at its top is covered with a ring of loam-lute, pressed against the conical bottom of the crucible, and secured in its place by means of two parallel rods *o*, *o*, which can be clamped by screws projecting horizontally from the vertical tunnel. See their places, indicated by two open dots near *s*, *s*.

A smelter and two laborers are employed in conducting a furnace; who make, with a mixture of equal parts of fire-clay, and cement of old pounds finely ground, the pots or crucibles, which last about four months. Five charges are made in 15 days; these work up from 6 to 10 tons of calamine, consume from 22 to 24 tons of coals, and produce 2 tons of zinc, upon an average. The following estimate of prices was made a few years ago:—

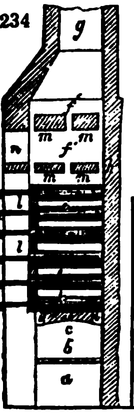
3 tons of calamine, at £6 - - - - - - -	£18	0	0
24 ditto coal, at 5*s*. - - - - - - - -	6	0	0
A smelter, at 2 guineas a week - - - - - -	2	2	0
Two laborers, each at 4*s*. per day - - - - -	2	16	0
Incidental expenses - - - - - - - - -	1	0	0
	£29	18	0

The calamine of Alston moor, used at Sheffield, is not so rich; it produces at most only 25 per cent. of zinc. The coals are laid down at a cost of 5*s*. 8*d*. per ton; and the calamine laid down there 5*l*.; whence the zinc will amount to 32*l*. 14*s*. per ton. The considerable importations of zinc from Belgium and Germany, for some years back, have caused a considerable fall in its price.

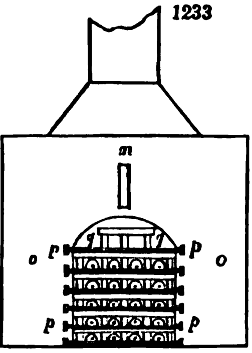
At Lüttich, where the calamine of Altenberg, near Aix-la-Chapelle, is smelted, a reduction furnace, containing long horizontal earthen tubes, is employed. The roasted calamine is finely ground, and mixed with from one third to two thirds its volume of coke or charcoal, broken to pieces the size of nuts.

Fig. 1233 represents this zinc furnace in elevation; and *fig.* 1234 in a vertical section through the middle. From the hearth to the bottom of the chimney it is 9 feet high, and the chimney itself is 18 or 20 feet high. *a*, is the ash-pit; *b*, the grate; *c*, the fireplace; *d*, the hearth; *e*, *e*, the laboratory; *f*, the upper arch, which closes in the laboratory; *f'*, the second arch, which forms the hood-cap of the furnace; *g*, the chimney; *h*, the fire-wall, which rests against a supporting wall of the smelting-house. Through the vaulted hearth the flame of the fire draws through ten flues *i*, *i*, two placed in one line; betwixt these five pairs of draught-openings, upon the sole of the hearth, the undermost earthen tubes *k*, immediately rest. The second and third rows of tubes *k*, *k*, lie in a parallel direction over each other, at about one inch apart; in the sixth row there are only two tubes; so that there are 22 tubes altogether in one furnace. At their two ends these tubes rest

1234



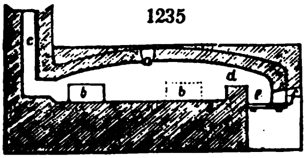
1233



upon fire-tiles, which form, with the side-walls, a kind of checker-work *l*, *l*. The tubes are 4 feet long, 4 to 5 inches in diameter within, five fourths of an inch thick. The fire, which arrives at the laboratory through the flues *i*, *i*, plays round the tubes, and passes off through the apertures *m*, *m*, in both arches of the furnace, into the chimney. *n*, is an opening in the front wall between the two arches, which serves to modify the draught, by admitting more or less of the external air.

The two slender side walls *o*, *o*, of the furnace, are a foot distant from the checker-work, so that on the horizontal iron bars *q*, *q*, supported by the hooks *p*, *p*, the iron receivers *r*, *r*, may have room to rest at their fore part. These receivers are conical pipes of cast iron, 1½ foot long, posteriorly 1½ inch, and anteriorly 1 inch wide at the utmost. After the earthen tubes have been filled with the ore to be smelted, these conical pipes are luted to them in a slightly slanting position. These cones last no more than three weeks; and are generally lengthened with narrow-mouthed wrought-iron tubes, to prevent the combustion of the zinc, by contact of air. When the furnace is in activity, a blue flame is to be seen at the mouths of all these pipes. Every two hours the liquefied metal is raked out into a shovel placed beneath; and in 12 hours the charge is distilled; after which the tubes are cleared out, and re-charged. 100 pounds of metallic zinc are the product of one operation. It is remelted at a loss of ten per cent., and cast into moulds for sale.

1235



1236

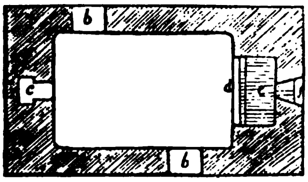
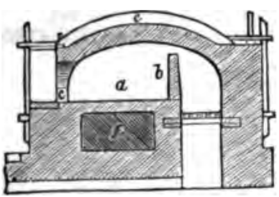
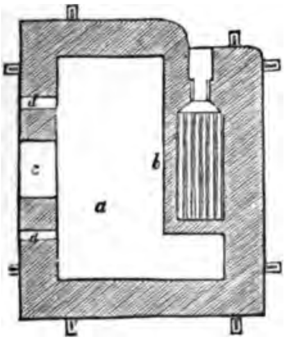


Fig. 1235 is a longitudinal section of the furnace for calcining calamine in Upper Silesia; *fig.* 1236 is a ground plan of the furnace. *a*, is the orifice in the vault or dome, for the introduction of the ore; *b*, *b*, apertures in the side-walls, shut with doors, through which the matter may be turned over; *c*, the chimney; *d*, the fire-bridge; *e*, the grate; *f*, the feed opening of the fire, the fuel being pitcoal. The calamine is stirred about every hour; and after being well calcined during 5 or 6 hours, it is withdrawn; and a new charge is put in. These Silesian furnaces admit of 30 cwts. at a time; and for roasting every 100 cwts. 15 Prussian bushels of fuel, equal to 28 English bushels, are employed. These calcining furnaces are sometimes built alongside of the zinc smelting-furnaces, and are heated by the waste flame of the latter. The roasting is performed in the Netherlands in shafts, like small blast iron-furnaces, called schachtofen.

1237



1238

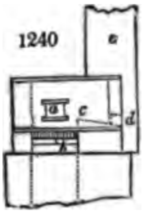


The hearth *a*, in *figs.* 1237, 1238, is constructed for working with 5 muffles, one of which is long, and four short. The muffles are made upon moulds, of fire-clay mixed with ground potsherds. The receivers are stoneware bottles. The grate is ten inches beneath the level of the hearth. *b*, the firebridge, is proportionally high to diminish the force of the flame upon the hearth, that it may not strike the muffles. *c*, is the opening through which the muffles are put in and taken out; during the firing it is partly filled with bricks, so that the smoke and flame may escape between them; *d*, *d*, are openings for adjusting the positions of the muffles; *e*, cross hoops of iron, to strengthen the brick arch; *f*, is a bed of sand under the sole of the hearth. During the first two days, the fire is applied under the grating; the heat must be very slowly raised to redness, at which pitch it must be maintained during two days. From 8 to 10 days are required for the firing of the muffles.

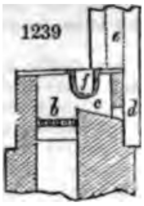
The furnace shown in *figs.* 1239, 1240, 1241, is for the melting of the metallic zinc. *Fig.* 1240 is a front view; *fig.* 1239 a transverse section; *fig.* 1241 a view from above; *a*, is the fire-door; *b*, the grate; *c*, the fire-bridge; *d*, the flue; *e*, the chimney; *f*, *f*, *f*, cast-iron melting-pots, which contain each about 10 cwts. of the metal. The heat is moderated by the successive addition of pieces of cold zinc. The inside of the pots should be coated with loam, to prevent the iron being attacked by the zinc. When the zinc is intended to be aminated, it should be melted with the lowest possible heat, and poured into hot moulds.

When the zinc ores contain cadmium, this metal distils over in the form of brown oxyde, with the first portions, being more volatile than zinc.

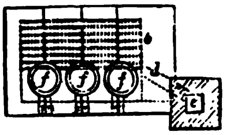
1240



1239



1241



Under Brass and Copper, the most useful alloys of zinc are described. The sulphate, vulgarly called white vitriol, is made from the sulphuret, by roasting it gently, and then exposing it upon sloping terraces to the action of air and moisture, as has been fully detailed under Sulphate of Iron. The purest sulphate of zinc is made by dissolving the metal in dilute sulphuric acid, digesting the solution over some of the metal, filtering, evaporating, and crystallizing.

Sulphate of zinc is added as a drier to japan varnishes.

The ordinary zinc found in the market is never pure; but contains lead, cadmium, arsenic, copper, iron, and carbon; from some of which, it may be freed in a great degree by distillation; but even after this process it retains a little lead, with all the arsenic and cadmium. The separation of the latter is described under Cadmium. Zinc, free from other metals, may be obtained by distilling a mixture of charcoal and its subcarbonate, precipitated from the crystallized sulphate by carbonate of soda. By holding a porcelain saucer over the flame of hydrogen produced from the action of dilute sulphuric acid upon any sample of the zinc of commerce, the presence of arsenic in it may be made manifest by the deposite of a gray film of the latter metal. Antimony, however, produces a somewhat similar effect to arsenic.

Zinc is extensively employed for making water-cisterns, baths, spouts, pipes, plates for the zincographer, for voltaic batteries, filings for fire-works, covering roofs, and a great many architectural purposes, especially in Berlin; because this metal, after it gets covered with a thin film of oxyde or carbonate, suffers no further change by long exposure to the weather. One capital objection to zinc as a roofing material, is its combustibility.

Chloride of zinc has been recently used with great advantage as an escharotic for removing cancerous tumors, and healing various ill-constitutioned ulcers. It, as also the nitrate, forms an ingredient in the resist pastes for the pale blues of the indigo vat.

Spelter (zinc) imported for home consumption—in 1835, 52,604 cwts.; in 1836, 47,406 cwts. Duty—in cakes, 2*s.*; not in cakes, 10*s.* per cwt.

THE END.